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# ANNALS

OF THE

## SOUTH AFRICAN MUSEUM.

VOLUME VII. containing:—

DESCRIPTIONS OF THE PALÆONTOLOGICAL MATERIAL  
COLLECTED BY THE MEMBERS OF THE GEOLOGICAL SURVEY  
OF CAPE COLONY AND OTHERS.

PART II. containing:—

- 3.—*The Invertebrate Fauna and Palæontological Relations of the  
Uitenhage Series.* By F. L. KITCHIN, M.A., Ph.D., F.G.S.  
With Ten Plates and One Text-figure.



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3.—*The Invertebrate Fauna and Palæontological Relations of the Uitenhage Series.*—By F. L. KITCHIN, M.A., Ph.D., F.G.S.

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I.—INTRODUCTION.

THE marine invertebrate fossils collected in 1900 by Mr. A. W. Rogers and Mr. E. H. L. Schwarz from the Uitenhage Series, and forwarded to me by Mr. Rogers on behalf of the Geological Commission, were found at localities near Uitenhage and below this on the Zwartkop's River, and in the valley of the Sunday's River near and below Dunbrodie. Further materials have been sent from the South

African Museum, principally comprising specimens presented by R. Rubidge and C. A. Fairbridge, and I have also received a small but interesting collection of Mollusca found by Miss M. Wilman in the Uitenhage strata exposed in the Coega neighbourhood. In addition to the marine fossils obtained by Messrs. Rogers and Schwarz, some shells of the genus *Unio* were collected in the Bezuidenhout's Valley below Blue Cliff.

In 1905 Mr. Rogers devoted some time to a further examination of the Uitenhage beds in the valleys of the Sunday's River and Coega River, and made an additional collection of fossils; he also obtained a few specimens from an exposure of Uitenhage beds at Brentford, in Knysna.\* The results of an examination of these supplementary materials have been incorporated in the following account, which has been withheld from publication for this purpose.

In view of the extensive manner in which the fauna of the Uitenhage Series has already been made known, particularly by the writings of Krauss, Sharpe, Tate, and Neumayr, it is not surprising to find that among the specimens collected during the preliminary survey in the Uitenhage and Port Elizabeth Divisions comparatively few new forms are represented. It could be gathered, however, from the published account of this survey,† that more prolonged search would in all probability add materially to an already lengthy list, and, in fact, the specimens obtained by Mr. Rogers in 1905 well bear this out, for they include a larger proportion of new species than that shown by the collections made in 1900.‡

In the following pages I have discussed the present state of our knowledge regarding the palæontological relations of the fauna, so far as concerns the invertebrate remains, and then proceeded to the description of the new materials submitted to me, while adding critical remarks and supplementary descriptions relative to some of the forms already known. Opportunity is also afforded by the present study to describe and figure two Uitenhage ammonites which are represented by specimens preserved in the collection of the Geological Society of London, though not included in the material sent to me from Cape Town; it is useful to have some account of these, both for the sake of comparison with other members of the

\* A new locality for Uitenhage marine fossils; see Schwarz (2), pp. 50, 74. [The numbers in parentheses after the names of authors, in this and subsequent references to literature, correspond with the titles of works bearing the same number under the names of those authors in the bibliographical list with which this memoir concludes.]

† Rogers and Schwarz (1).

‡ For an account of the survey of 1905, see Rogers (2).



same genus which occur in the Uitenhage beds and in order to broaden the foundation for future work.

From statements made in the Reports mentioned above, it seems that in our present state of knowledge no satisfactory subdivision of the Uitenhage beds is possible, and that the members of the series are so variably developed that no consistent nomenclature is to be hoped for until detailed mapping can be carried out. Of the subdivisions hitherto employed, the uppermost member of the series, the Sunday's River or Marine Beds, has yielded the majority of the Mollusca which are discussed in this paper. The underlying "Wood Bed" series has also furnished a few species of marine molluscs in addition to *Unio* and remains of fossil plants. The so-called Enon Beds represent the lowest division of the formation in this district. Messrs. Rogers and Schwarz, while indicating the local significance of the adopted subdivisions, draw attention to the limited value of this nomenclature, and mention facts which clearly show the contemporaneous variation of facies in the series. Thus, to the north of Uitenhage, the Marine Beds appear to be synchronous with part of the local conglomerate of "Enon" character, and it is pointed out that at Plettenberg's Bay also, the Sunday's River Beds are partly replaced by conglomerate resembling that of the Enon Beds, but here yielding *Trigonia conocardiiformis*, one of the most characteristic fossils of the Marine Beds.\*

The question of the age to be assigned to the Uitenhage Series, as is well known, has called forth strikingly different opinions from various authors. It was suggested by Stow in 1871† that the want of unanimity among the earlier writers might have been due to careless collecting and the mingling of specimens obtained from different horizons. This author therefore made his own collections with due regard to the localities and the individual bands in which he found the fossils to occur, and he attempted a correlation of the fossiliferous beds exposed in sections at various places on the Sunday's and Zwartkop's Rivers. It appears highly probable, however, from the palæontological evidence alone, that no very considerable extent of time is represented by the whole of the beds which yield marine fossils, and there is nothing to show that the different opinions respecting the age of the series have been arrived at in consequence of any radical change in the character of the fauna itself in its distribution through the strata. That any such marked change can be

\* Schwarz (1), pp. 53, 61; Rogers and Schwarz (1), p. 5; Rogers (1), pp. 282-296. See also Rogers (2), pp. 13, 15.

† Stow (1).

traced is not evident from the table of sections given by Stow.\* There are, no doubt, minor differences, and local distribution according to facies in the successive fossiliferous bands, which may be more clearly revealed when the district comes to be mapped in detail; but there is certainly nothing so far-reaching in this respect as to have formed grounds for the differences of view expressed, for instance, by Tate, who ascribed an Oolitic age to the fauna, and Neumayr, who referred these beds to the Neocomian.†

The divergent conclusions arrived at by the earlier authors appear rather to have resulted from the different interpretations put upon the same peculiar association of forms when viewed in comparison with the limited standards of European type. The principal difficulty seems to have lain in the fact that none of the fossils could be correctly identified with those of formations studied in other regions, and the facies of the fauna, taken as a whole, did not seem to show such agreement with that of any known assemblage as to give it the decided stamp which might serve to put the question of age beyond dispute. This matter has been so frequently dealt with, and its bearings are so well known, that it may seem superfluous to dwell upon it here at any length; but it may be useful to recapitulate briefly the successive opinions expressed, and in some cases the grounds upon which they were based, before proceeding to the more thorough comparison of the fauna with its extra-European equivalents which recent knowledge has rendered possible.

I take this opportunity of expressing my indebtedness to Mr. A. W. Rogers for the helpful manner in which he has furnished me with information relating to the collections; to Dr. A. Smith Woodward, Mr. G. C. Crick, and Mr. R. B. Newton for facilitating reference to literature and specimens in the British Museum (Natural History); and to Mr. W. Rupert Jones for his ready assistance during my repeated examinations of the extensive collection of Uitenhage fossils in the museum of the Geological Society of London. My best thanks are also due to Prof. J. W. Gregory for examining a specimen of *Thamnastræa* submitted to him, and to Mr. C. D. Sherborn for assistance in a few matters relating to bibliography; to Mr. G. W. Lamplugh, Mr. H. A. Allen, and Mr. H. Woods, I am indebted for several useful suggestions.

\* Stow (1), fig. 3. See further remarks on this subject at the end of Section II. of the present paper.

† In this connection see Neumayr's remarks on Stow's work; Holub and Neumayr (1), p. 270, footnote 6



## II.—THE AGE OF THE FAUNA.

(a) *Summary of Previous Work.*—In 1837, Hausmann recorded the occurrence of some shells obtained by Hertzog from strata in the Sunday's River district, to which he ascribed a Lower Cretaceous age. These included a *Hamites*, which was compared with *H. intermedius* J. Sow. and *H. funatus* Brongn., and a *Trigonia* which was thought to resemble *T. dædalea* Park.\* Goldfuss afterwards described and figured two of Hausmann's shells under the names *Lyrodon herzogi* and *Cytherea herzogi*, and also considered them to be of Greensand age.†

The examination of a small collection of lamellibranchs obtained by F. Krauss in 1839 from strata exposed on the Zwartkop's River, led that author to the conclusion that they indicated a Lower Greensand horizon,‡ and in another paper Krauss furnished excellent descriptions and figures of these shells, maintaining a similar view concerning their age.§

In 1851 a collection of fossil plants and molluscs, obtained by R. Rubidge on the Sunday's River, was exhibited before the British Association at Ipswich by Colonel Portlock, who remarked that the shells were apparently of Jurassic age, while Dr. Harvey's examination of the plant remains was thought to corroborate this view.||

In his well-known paper published in 1856, A. G. Bain¶ referred the Uitenhage fossils with doubt to the Lias, basing this opinion upon the prevalence of a supposed Liassic form, "*Gryphæa incurva*." The shell mistaken for this, however, was *Exogyra imbricata*, previously described by Krauss, which, as we shall see, bears only a superficial resemblance to the *Gryphæa* mentioned, and is in reality closely comparable with certain Lower Cretaceous forms of *Exogyra*. Appended to Bain's paper were D. Sharpe's descriptions of the Secondary fossils collected by Atherstone and Bain from localities on the Sunday's and Zwartkop's Rivers. The forms described, principally Mullusca, led Sharpe to the conclusion that they most nearly resembled European species of the Middle and Lower Oolites; he compared his *Ammonites atherstoni* with *A. macrocephalus* and *A. herveyi*, while believing *Ammonites baini* to be related to *A. humphresianus* and other Lower Oolitic forms.

\* Hausmann (1), p. 1457.

† Goldfuss (1), Band II., p. 202, pl. 137, fig. 5 (1837); p. 239, pl. 149, fig. 10 (1840).

‡ Krauss (1), pp. 129, 130.

§ Krauss (2).

|| Portlock (1).

¶ Bain (1).

In 1867, a paper by Ralph Tate,\* in which many new forms were described and figured, added largely to our knowledge of the Uitenhage fossils, and this author was led to some remarkable conclusions from his study of the fauna. He believed the assemblage to indicate a Jurassic age, and stated that he thought it to represent the fauna of the Oolitic rocks of Europe, and to approximate to that of the Great Oolite. It seems clear that in instituting this comparison, he made use of some molluscan types little adapted to serve the purposes of a critical correlation, and he was at the same time misled by several quite erroneous identifications. He also misunderstood the affinities of the cephalopods and the significance of certain *Trigonia* which alone might have been expected to form obstacles to his conclusions. It is here scarcely necessary to do more than refer to the curious generalisation arrived at by Tate concerning the relation of these supposed Jurassic deposits to the Jurassic strata of Europe, namely, that the "Oolites" of South Africa are the representatives of the whole of the Jurassic rocks of Europe with the exception of the Upper Oolites, and illustrate an intermingling of palæontological types which are analogous to, or identical with, those distributed in successive zones in Europe.

In his monograph on the Cretaceous lamellibranchs of Southern India, Stoliczka† made some reference to Uitenhage forms. He evidently believed Tate's *Crassatella complicata* to belong to the genus *Ptychomya*, and he ascribed *Astarte herzogi* Krauss to Speyer's genus *Grotriania*. He further expressed the opinion that Krauss's *Astarte bronni* might belong to the Cretaceous genus *Remondia* Gabb, and thought that in addition to these and *Trigonia ventricosa*, several other Uitenhage shells show a Cretaceous rather than a Jurassic aspect; attention was drawn to the great similarity between *Trigonia ventricosa* (Krauss) and the Cretaceous *T. tuberculifera* Stol., from Southern India. While we shall see that Stoliczka rightly recognised some of the Uitenhage forms to exhibit Cretaceous affinities, he was in error in ascribing *Astarte herzogi* to the genus *Grotriania*, and, as afterwards pointed out by Neumayr, wrongly supposed *Astarte bronni* to belong to the genus *Remondia*. *A. bronni* is so distinctly characterised that Neumayr proposed for it the new generic name *Seebachia*—a fact which appears to have been overlooked by Stanton, who in 1897 still tentatively included it in the genus *Remondia*.‡

One of Tate's Uitenhage species, the so-called *Crassatella com-*

\* Tate (1).

† Stoliczka (2), pp. 286, 294, 315 (1871).

‡ Stanton (1).



*plicata*, was later also recognised by Dames to be a representative of the genus *Ptychomya*,\* and this seemed to point to a later age for the strata from which it was obtained than that assigned by Tate. Dames was further led to the belief in the Neocomian age of the Uitenhage beds by a fragment of an ammonite (sent by Krauss to L. von Buch) which he thought to be identical with *Ammonites astierianus* d'Orb.

In the concluding chapter of his monograph on the British Fossil *Trigonia*, Lycett† referred briefly to the *Trigonia* of the Uitenhage Formation, and expressed his opinion that some of the most characteristic of these point decisively to a Cretaceous age; he also showed that the alleged occurrence of *T. goldfussi*, which Tate had used as evidence for a Jurassic age, rested on an erroneous determination.

The whole question of the age of this fauna was afterwards well handled by Neumayr,‡ who subjected Tate's work to some criticism. Neumayr set on one side many molluscan types as of little significance in a comparative study, and concluded that a costate *Trigonia* (*T. tatei* Neum.) alone exhibited a marked Jurassic character. On the other hand, he considered a number of forms to represent essentially Cretaceous types. Such were *Holcostephanus atherstoni* (Sharpe); *Holcostephanus baini* (Sharpe); *Crioceras spinosissimum* (Hausm.) Neumayr; *Trigonia ventricosa* (Krauss); *Trigonia cono-cardiiformis* (Krauss); *Ptychomya complicata* (Tate)§; and *Exogyra imbricata* Krauss. He suggested that Tate's *Ammonites subanceps*, which was thought by Tate to resemble the Jurassic *A. anceps* Rein., might really represent the young of *Crioceras spinosissimum*. It was admitted by Neumayr that *Belemnites africanus* Tate, which Tate placed in the group *Canaliculati* and considered to afford strong evidence for an Oolitic age, bears a strong resemblance to the Jurassic forms *B. canaliculatus* Schloth. and *B. magnificus* d'Orb.; but at the same time he drew attention to the existence of a belemnite in the Lower Cretaceous of North Germany which seemed to share some of the characteristics of *B. africanus*. In a later paper, written after an examination of Tate's original specimen in the collection of the Geological Society, Neumayr|| definitely separated *B. africanus* from the *Canaliculati*, and included it in his group of the *Absoluti*, which, as he remarked, extend in their occurrence up to the Aptian; hence the conclusive nature of the

\* Dames (1).

† Lycett (3), p. 230 (1879).

‡ Holub and Neumayr (1).

§ Misquoted "*implicata*" by Neumayr.

|| Neumayr (4).



evidence for age furnished by the occurrence of *B. africanus* in the Uitenhage beds was no longer to be recognised.\* Neumayr's argument for the Lower Cretaceous age of this fauna appears indeed to be overwhelmingly strong, particularly in the evidence of the Cephalopoda, all of which he found to possess near allies in European Neocomian forms. Regarding the two species of *Holcostephanus*, Neumayr pointed out that their resemblance to the Jurassic types with which they had previously been brought into comparison was only of a superficial character, depending alone on a certain outward similarity of habit.

Pavlow† has since confirmed this view, after studying South African specimens, and has placed *Holcostephanus atherstoni* and *H. bairdi* in his generic or sub-generic division *Astieria*, which comprises numerous Neocomian types; he even goes so far as to identify *Holcostephanus atherstoni* with *H. psilostomus* Neum. and Uhlig,‡ from the Hilsthon of North Germany, and to the same form he ascribes a shell from the Neocomian of Speeton.

In view of the fact that the plant remains found in the Uitenhage beds had previously been thought to point rather to an Oolitic than a Cretaceous age, and having regard to the division of opinion concerning the affinities of the invertebrate fauna, Messrs. Rogers and Schwarz, in 1901, were led to adopt the provisional conclusion that the Uitenhage Series may be assigned to the Upper Jurassic.§ In stating this, they mention that the fauna and flora have been considered to resemble in some degree those of the Jurassic series in Cutch. It is well known that the resemblance between certain lamellibranchs of the Uitenhage beds and those of the Oomia Group in Cutch has been frequently remarked upon, but it can no longer be maintained that the marine Oomia strata are in reality of Jurassic age, at least so far as concerns the *Trigonia*-beds; but this is a point to which we may presently return, and one which we may consider in greater detail.

In more recent works Mr. Rogers|| gives us a comprehensive account of the Uitenhage Series, and now considers these beds to represent a portion of the Cretaceous system. The same view is adopted by Drs. Hatch and Corstorphine in their "Geology of South Africa" (1905). With reference to the flora, Prof. A. C.

\* See also Neumayr (5).

† Pavlow and Lamplugh (1), pp. 492-497 (134-139 in authors' copy).

‡ Neumayr and Uhlig (1), p. 149, pl. xxxii., fig. 2.

§ Rogers and Schwarz (1), p. 17.

|| Rogers (1), pp. 281-318; Rogers (2), pp. 15-33, 45.

Seward, in his memoir on the subject,\* has shown that the Uitenhage plants "include types in part characteristic of Wealden and in part indicative of Jurassic floras"; but he believes that the balance of evidence derived from the plants is in favour of a Wealden age.

We thus see that recent authoritative opinions have lent strong confirmation to the views of the earliest writers who made a study of this fauna. Other works in which less critical reference has been made to the age of the Uitenhage Series may now be briefly noticed.

In 1857, W. G. Atherstone suggested the partly Jurassic and partly Cretaceous age of the Uitenhage beds,† but Andrew Wyley, in 1859, placed the Enon Beds so low as the New Red Sandstone, and correlated the Sunday's River Beds with the Jurassic (Oolites).‡

Feistmantel§ evidently shared Tate's view of an Oolitic age when he tried to show affinities between certain Mollusca from the Uitenhage beds and others from the Oomia Group in Cutch in order to prove the Lower Oolitic age of the Oomia fauna and bring about harmony between the evidence for age furnished by the plants and animals from those beds. In a correlation of the Indian and African Mesozoic formations the same author also tabulated the Uitenhage Series as Jurassic.|| G. W. Stow divided the formation into a "Lower Jurassic" and an "Upper Jurassic" series.¶ In 1878 W. T. Blanford, basing his view upon a study of Tate's and Stow's papers, concluded that the beds containing *Hamites* yielded too large a number of Middle Jurassic forms for reference to the Neocomian; but he believed them to represent a very high Jurassic horizon, while pointing out that *Trigonia ventricosa* and *T. vau* were still higher.\*\*

In 1880 Griesbach classed the Uitenhage beds as Jurassic,†† while the same view was adopted by T. Rupert Jones in 1884 ‡‡ and by Moulle in the following year.§§ Even so recently as 1897, Futterer has accepted Sharpe's and Tate's conclusions.|||| On the other hand, Gürich,¶¶ Schenck,\*\*\* and Molengraaff ††† have referred these beds

\* Seward (1), p. 46.

† Atherstone (1), pp. 584, 588.

‡ Wyley (1). [I have not seen Wyley's Report, but his correlation is set forth in Tate (1), p. 172, and Corstorphine (1), Appendix.]

§ Feistmantel (1).

|| Feistmantel (4), pp. 54, 59, 84.

¶ Stow (1).

\*\* W. T. Blanford (1), p. 118.

†† Griesbach (1), pp. 90, 93.

‡‡ Jones (1); Jones (2), p. 737.

§§ Moulle (1), p. 216.

|||| Futterer (1), p. 625.

¶¶ Gürich (1).

\*\*\* Schenck (1), p. 231.

††† Molengraaff (1). [I have not been able to see this work, but quote the statement and reference on the authority of Newton (2), p. 146.]



to the Lower Cretaceous; but in a more recently published tabular correlation of the geological formations of the Transvaal and Cape Colony, Molengraaff has ascribed them with a note of interrogation to the Middle Jurassic.\* In 1896 R. B. Newton published a useful summary of previous work on the Cretaceous conchology of South Africa,† and furnished a complete list of the known Mollusca from the Uitenhage beds, which he classed as Neocomian. In their textbooks de Lapparent‡ and Kayser§ have followed Holub and Neumayr in assigning a Neocomian age. Passarge, in his work on the Kalahari,|| has tabulated the Uitenhage Series with the Upper Jurassic and Lower Cretaceous. Lemoine believes it to be of Lower Cretaceous age.¶

(b) *Additional Evidence for Age.*—We see from the foregoing that a comparison of the Uitenhage Mollusca with European forms seems to point definitely to a Lower Cretaceous age, for it will be conceded that the evidence of the Cephalopoda must be allowed to carry the greatest weight in influencing a decision. The representatives of *Holcostephanus* (sensu stricto), *Hamites* and *Crioceras* already recorded, supply in themselves sufficiently striking evidence, and notable additions to these are other forms of *Holcostephanus*, as well as representatives of *Acanthodiscus* and *Bochianites* included in the collections submitted for examination and described in these pages. Two other species of *Holcostephanus* (sensu stricto), hitherto undescribed, are represented in the collection of the Geological Society of London. One of these is apparently allied to *H. atherstoni* (Sharpe), but has greater lateral compression as well as other distinctive characters. It closely resembles *H. psilostomus* Neum. and Uhlig, of the European Neocomian, and is the “compressed variety” of *H. atherstoni* mentioned by Pavlow,\*\* who aptly suggested close relationship to a shell from the Neocomian of Spain, figured by Nicklès as *Holcostephanus hispanicus*. The significance of such an assemblage of Cephalopoda in the Uitenhage beds cannot be mistaken, quite apart from the bivalve forms to be mentioned below and a representative of the Crustacean genus *Meyeria*. In Europe the known species of *Holcostephanus* (sensu stricto) are almost wholly, if not entirely, confined to strata of Upper Valanginian and Lower Hauterivian age.

In his paper on the Uitenhage fauna R. Tate †† gave a tabular list

\* Molengraaff (2), p. 119.

† Newton (2).

‡ de Lapparent (1), p. 1267.

§ Kayser (1), p. 444.

|| Passarge (1), p. 82; see also p. 597.

¶ Lemoine (1), pp. 383, 389.

\*\* Pavlow and Lamplugh (1), pp. 492, 496, (134 and 138 of authors' copy).

†† Tate (1), p. 166.

of some of the more important fossils, together with their supposed extra-African allies and analogues, which, with one exception, were thought to be Jurassic. An examination of this list shows, however, that a different construction must now be put upon the comparisons, as may be demonstrated by the mention of a few examples. In addition to *Holcostephanus atherstoni* and *H. bairdi*, which were erroneously thought to be allied to well-known Oolitic forms, there is Tate's *Ammonites subanceps*, a single specimen, regarding which that author wrote: "It is doubtful whether this be not a mere variety of *A. anceps* Reinecke, of the Middle Oolites." As already mentioned, Neumayr thought that it might represent a stage in the individual growth of *Crioceras spinosissimum*, which he supposed to have had the whorls in contact at such an immature period. This may be a correct view, but it seems equally probable that we are dealing with an immature example of some species of *Hoplites* (sensu lato). Tate's specimen, of which his published figures convey a very imperfect and even misleading impression, shows great similarity to certain forms which have been ascribed by Sayn to *Hoplites arnoldi* (Pict. and Camp.), and by Toucas to *H. bottellæ* Kilian. These were thought by Pavlow to have been wrongly identified, and are united by him under the name *Hoplites heteroptychus*, which has more recently been included by Uhlig in his narrower generic group *Solgeria*. A somewhat similar form has been described and figured by Bogoslowsky under the name *Hoplites* aff. *arnoldi* Pict., and this is said to occur with *Belemnites lateralis* Phill. above the "Rjasan-Horizont" in Russia (Mostja River).\* *Hoplites subanceps* is more closely and less coarsely ornamented than this, but there are points of agreement in the type of sculpture. Further observations on "*Ammonites*" *subanceps* are given in the remarks which follow the description of a specimen ascribed to *Acanthodiscus* sp., in the following pages.

*Ostrea jonesiana* Tate was compared by Tate with *O. costata* Sow. from the Oolites; but it is in reality a true *Exogyra* quite comparable with shells of the type of *E. subplicata* Roem.,† from the Hilsconglomerat of North Germany.

*Pecten projectus* was compared with *P. lens* Sow., but such a comparison must have little value when we remember that species of *Pecten* with similar broad characteristics recur at various horizons and are not confined to the Jurassic rocks. *Pecten projectus*, in

\* Bogoslowsky (1), pp. 112, 138; Taf. vi., fig. 7.

† F. A. Roemer (1), Nachtrag, p. 25, pl. xviii., fig. 17; F. A. Roemer (2), p. 47 (1840).



fact, compares more satisfactorily with some of the Cretaceous forms.

The comparison of *Pecten rubidgeanus* with *P. subspinosus* Schloth. cannot be pronounced at all fortunate, while we shall find that *Lima obliquissima* shows a closer agreement of characters with Cretaceous and later forms than with the European Jurassic shells cited by Tate.

*Placunopsis subjurensis* Tate, which was compared with *P. jurensis* Roem., may perhaps be an *Anomia*, and in some respects closely resembles *A. pseudoradiata* d'Orb.,\* from the Aptian. *Placunopsis imbricata* Tate is compared in the table with *P. substriata* Lyc., from the Oolites. *P. semistriata* (Bean) was probably the English shell with which it was intended to institute comparison, since this name alone is mentioned in Tate's description on page 154 of his paper. *P. imbricata*, however, is without radial ornamentation, but is characterised by well-spaced concentric ridges which recall the similar ornamentation of *Anomia neocomiensis* d'Orb., † though occurring in less emphasised form. The illustration of *P. imbricata* gives a very poor idea of the shell, but an examination of the specimen dispels the notion of a close comparison with known Jurassic forms.

*Trigonia cassiope* Tate is not to be united with any known Jurassic costate *Trigonia*, and was accordingly renamed *T. tatei* by Neumayr. It is well distinguished by the elongated escutcheon, the very delicate marginal carina, and the fine character of the ornamentation on the area and escutcheon. *Trigonia goldfussi* Tate is an immature shell, and in all probability illustrates the youthful stage of one of the large and robustly ornamented *Pseudo-quadratae* which form such a striking feature in the Uitenhage fauna. It certainly does not represent either *Trigonia goldfussi* Agassiz or *T. painei* Lyc. (= *T. goldfussi* Morr. and Lyc.), with which it was identified. Tate himself, on page 159 of his paper, said: "Hereafter, however, it may be found to be the young of a distinct species." It is therefore the more regrettable that the error of quoting this European Jurassic shell from the Uitenhage beds should have continued to be perpetrated. Stow ‡ repeatedly used the name "*T. goldfussi*" in his paper, but I have been unable to ascertain to which of the *Trigoniae* he referred.

No importance can be attached to the comparison of such types as

\* d'Orbigny (4), p. 84; Woods (3), vol. i., p. 27, pl. v., figs. 1-3 (1899).

† d'Orbigny (3), p. 754, pl. 489, figs. 1-3 (1848).

‡ Stow (1), pp. 497-514.

*Pinna atherstoni* Sharpe and *P. sharpei* Tate with Jurassic forms, for it is evident that these representatives of the genus lack any strong distinctive characters which alone would render them of value in an estimate of geological age.

*Mytilus baini* Sharpe was compared with *M. sowerbianus* d'Orb., from the Oolites of Europe. It is a *Modiola* which certainly has characters of form and ornamentation closely similar to those which distinguished *M. sowerbiana* (d'Orb.) and *M. perplicata* (Etallon); but this type of *Modiola* is by no means confined to Jurassic rocks, having also a widely distributed representative in the Cretaceous *M. flagellifera* (Forbes), to mention a well-known example.

*Pholadomya dominicalis* Sharpe was thought to resemble Liassic and Oxfordian forms, but it may equally well be brought into comparison with Lower Cretaceous representatives; for example, the European Aptian shell ascribed, rightly or wrongly, to *P. pedernalis* Roem.\*

*Astarte pinchiniana* Tate was brought into comparison with *A. pumila* Goldf. and *A. excentrica* Morr. and Lyc., from the Great Oolite of Europe. The African shell differs in important respects from these, and, as will be pointed out below, it probably belongs to the sub-generic group *Eriphyla* and is certainly most closely comparable with Cretaceous forms.

*Berenicea antipodum* Tate was believed by Tate to be related to *B. striata* Haime, from the Lower Lias of France, but has been regarded by Prof. J. W. Gregory † as a close ally of the Cretaceous *B. gracilis* (Milne Edwards).

Two Uitenhage *Serpula* were identified by Tate with *S. filaria* Goldf. and *S. plicatilis* Münster., from the Inferior Oolite of Europe. The specimens ascribed to *S. plicatilis* represent an adherent form sharply carinated on the back, with a weaker carinal angle on either side and a circular aperture, but the true *S. plicatilis* Goldf. has only a single central, longitudinal keel. *S. quinquangularis* Goldf. ‡ (Upper Jurassic) stands much closer in its characters, and a *Serpula* scarcely distinguishable from this occurs in the Lower Cretaceous of Europe, and may be found named *S. quinquangularis* in some collections. *S. filaria* Goldf. is a solitary, wholly adherent form, commencing with a coiled stage. So far as can be seen from the imperfect African specimen named *S. filaria* by Tate, this is a clustering form consisting of crowded, narrow cylindrical tubes, and

\* Pictet and Renevier (1), p. 60, pl. vi., fig. 7, 1855; Moesch (1), p. 93, pl. xxxiii., fig. 2.

† Gregory (1), p. 112.

‡ Goldfuss (1), Band i., p. 230, pl. 68, fig. 8 (1831).



it is not distinguishable from the English Lower Cretaceous *Serpula* that have been variously referred to *Serpula filiformis* J. de C. Sow., and *S. plexus* J. de C. Sow. We thus see that in the case of the two *Trigonia* and the two *Serpula* which Tate identified with European Jurassic types, the determinations were so far erroneous that they are now bereft of the significance which was attached to them as evidence for the age of the fauna.

We may further examine the evidence for age afforded by some of the more conspicuous bivalves, and firstly I may briefly refer to the representatives of the genus *Trigonia*, which in themselves lend such a characteristic aspect to the fauna. Although the testimony of these is perhaps not quite so conclusive as Lycett supposed, still, the balance of evidence furnished by members of this genus may be safely relied upon to give a fair indication of age, even when considered apart from associated forms, and the material we are dealing with in the present instance is fortunately of an exceptionally favourable character. In the first place there is *Trigonia ventricosa*, *T. kraussi*, and *T. rogersi*, all possessing the characters of the section Scabræ—a division which, so far as we know, is elsewhere only represented in rocks of Cretaceous age. These might be considered to be balanced by the occurrence of *T. tatei*, a typical member of the section Costatæ, but although this division of the *Trigonia* has its maximum development in the Oolitic rocks, it is also represented in strata of Lower Cretaceous and even later age.

*Trigonia peninsularis* Coquand,\* from the Aptian of Spain, certainly shows characters of degeneration not shared by *T. tatei*, but the Oomia strata of Cutch have yielded two normal representatives of the Costatæ, which, together with some degenerate derivatives of this section, are accompanied by *Trigonia* which exhibit a decidedly Cretaceous aspect. Another unmodified costate form, *T. angustecostata* Behr.† occurs in the Argentine Republic in strata which are regarded by Behrendsen as Upper Cretaceous, while a typical member of this section has been described by E. Ascher from the Grodischter beds (Hauterivian) of Silesia.‡

*Trigonia herzogi* (Goldf.), another very characteristic Uitenhage form, was believed by Lycett to belong to the Quadratæ, which, so far as known, are exclusively Cretaceous. Steinmann,§ however, pointed out that *Trigonia herzogi* differs in several important par-

\* Coquand (1), p. 129, pl. xxiii., fig. 3.

† Behrendsen (1), p. 6, pl. 3, fig. 7.

‡ Ascher (1), p. 159 [25], p. xiii. [ii.], fig. 10.

§ Steinmann (2).

ticulars from all known Quadratae, and found that the special features which distinguish this Uitenhage shell from the Jurassic Clavellatae on the one hand and the Cretaceous Quadratae on the other, are shared by *Trigonia transitoria* Steinm. from Lower Cretaceous rocks in Bolivia, Chili, and the Argentine Republic. He therefore suggested a new group-name, the Pseudo-quadratae, to comprise these two *Trigoniae*, which were the only examples known to exhibit these peculiar distinguishing characters. *Trigonia neuquensis* Burckhardt,\* which occurs with *T. transitoria* in Neocomian rocks at Las Lajas on the Rio Agrio (Argentine), falls under the same heading, while *T. mamillata* † from the Oomia strata in Cutch must also be referred to this group. Still another form, described in these pages (*T. holubi*), is clearly referable to the same category. Although the five members of the Pseudo-quadratae known to us are all similarly differentiated from the typical Clavellatae, it is not certain that they are all so closely related to one another as might at first sight appear to be the case; some, at least, may possibly have been independently evolved from clavellate ancestors. ‡ Nor is it by any means certain that they bear any close and direct relationship to the true Quadratae, and though definite indications on this point fail us, it is quite probable that the Quadratae and Pseudo-quadratae represent parallel and independent groups of derivatives arising from Jurassic Clavellatae. It is therefore evident that the *Trigoniae* of the group Pseudo-quadratae cannot yet be considered in themselves to furnish quite such reliable guidance to geological age as the true Quadratae, but at the same time their general aspect, by comparison with the Quadratae, strongly suggests a Cretaceous age, while the known South American representatives must, in fact, be regarded as Neocomian. Some of the most important features wherein the Quadratae differ from the Clavellatae are also exemplified in the Pseudo-quadratae. Lycett laid great emphasis on the presence or absence of sculpture on the escutcheon in distinguishing between the Jurassic Clavellatae on the one hand, and the Cretaceous Clavellatae and Quadratae on the other, and in regard to this feature all the Pseudo-quadratae agree with the Quadratae in having coarsely nodose ornamentation on the escutcheon. Further remarks on the points of agreement between these groups are appended to the description of *Trigonia holubi*.

*Trigonia conocardiiformis* (Krauss) was thought by Lycett to fall

\* Burckhardt (2), p. 74, Taf. xiv., figs. 4-6.

† Kitchin (1), p. 100, pl. ix., figs. 8, 9; pl. x., figs. 1-3.

‡ Remarks on this subject will be found to follow the description and the discussion of the relationships of *Trigonia holubi*, in these pages.



within the section *Scabræ*, but a near relationship to members of this division is scarcely to be inferred from the adult characters displayed by this peculiar form, while a study of the young shell does not plainly reveal its affinities. A general comparison, however, shows that this *Trigonia* differs from the Jurassic *Clavellatæ* in a manner somewhat analogous to that which distinguishes the *Scabræ*, and a very closely similar and probably intimately related form occurs in the Neocomian of the Argentine Republic.

On the whole, so far as this *Trigonia*-assemblage is comparable with European forms, it must certainly be considered to display a Cretaceous rather than a Jurassic character, though when regarded collectively, it is without counterpart in the European area. The significance of other *Trigoniæ* included in this fauna will be discussed presently.

Still further indications of geological age are to be derived from a comparison of the Uitenhage lamellibranchs with European types. One of the shells submitted to me, which proves to be identical with a form previously described by Sharpe, who did not recognise its true generic position, is an example of the well-characterised genus *Thetironia*, which in Europe is widely distributed in Lower Cretaceous and higher strata, though it has not been recorded from rocks of an earlier age. A second species of *Thetironia* is also included in the collection. *Solecurtus* is another genus not known to occur in rocks older than Cretaceous, and a representative of this must now be added to the list of Uitenhage molluscs. The specimens sent to me for examination also include examples of *Pecten* which can only be identified with the Cretaceous *P. orbicularis* J. Sow. and *P. cottaldinus* d'Orb., while a third form may be most aptly brought into comparison with *P. subacutus* Lam. A representative of the Cretaceous genus *Anthonya* must also be recorded in this connection.

*Gervillia dentata* Krauss, though belonging to the group of *G. aviculoides*,\* typically represented in Jurassic rocks (*G. deecki* Frech; *G. aviculoides* Sow.), has a close counterpart in *G. anceps* Desh. and *G. sub lanceolata* d'Orb., in the Lower Cretaceous of Europe. A form closely similar, and perhaps identical, occurs also in the Neocomian of German East Africa. The long lateral tooth which Krauss thought to be so highly distinctive of *G. dentata* as almost to justify the establishment of a new genus, is a normal feature of the group, and is well developed in *G. anceps*.† Another common

\* Frech (1).

† Frech (1), pp. 612, 613.

and characteristic Uitenhage shell is *Exogyra imbricata* Krauss, and this belongs to a general type well exemplified in the Lower Cretaceous strata of Europe and South America. *Lima neglecta* Tate, belongs to the sub-generic division *Mantellum*, and most closely resembles forms which occur in the Lower Cretaceous of Europe. Reference has already been made to *Ptychomya complicata* (Tate), which is a typical representative of a genus widely distributed in the Lower Cretaceous rocks, where it first makes its appearance.

It is abundantly evident, then, that many of the most important and distinctive molluscan forms, amongst those with which we are dealing, give similar indications of geological horizon. There can be no doubt, indeed, that the marine Uitenhage fauna is of Neocomian age, though it is perhaps not possible to arrive at a very precise and positive estimate of equivalence with the divisions of the Neocomian in Europe, owing to the want of close coincidence in the faunas as developed in such widely separated regions. But *Holcostephanus atherstoni* (Sharpe) and *H. wilmanæ* sp. nov., if not actually represented in Europe, have very close allies there in the Valanginian and Hauterivian, and the Uitenhage Marine Beds may, in my opinion, be certainly correlated with these divisions. Further, it seems to me highly probable that the Marine Beds represent not more than the strata at the top of the Valanginian and the base of the Hauterivian.

The possibility that the lowest marine strata may be of greater age than Neocomian is not only most remote, but is contradicted by the palæontological evidence, so far as this goes. Fossiliferous strata, yielding a marine molluscan fauna characterised by the prevalence of Gasteropoda and the remains of oysters, occur at Dunbrodie (Sunday's River) associated with plant-bearing beds, and are in the lower part of the Uitenhage Series; according to Messrs. Rogers and Schwarz they may be classed with the so-called "Wood Bed" series. Amongst the fossils collected here are *Actæonina atherstoni* (Sharpe), *Cyprina rugulosa* Sharpe, and a *Pecten* which I have identified as *Pecten cottaldinus* d'Orb. While *Actæonina atherstoni* is found also in the highest part of the Marine Beds on the Zwartkop's River and with the characteristic *Trigonia* on the Sunday's River, Stow recorded the occurrence of *Cyprina rugulosa* with similar associates. Although the Wood Bed series was not seen in the Zwartkop's River Valley below Uitenhage, the lowest part of the Marine Beds in the Zwartkop's River section, exposed in a clay-pit near Rawson Bridge, yielded *Actæonina atherstoni* and



shells most probably referable to *Bochianites glaber* sp. nov.; the latter has close affinities with European Neocomian forms and occurs at a higher level in the Marine Beds one mile from Rawson Bridge on the main line, up side. It is also worthy of remark that the lowest marine strata found, either at Dunbrodie or in the Zwartkop's River Valley, yielded no single form which suggests stronger affinities to Upper Jurassic than to Lower Cretaceous types; but those very forms, such as *Trigonia tatei* Neum. or *Tancredia schwarzi* sp. nov., which if considered alone might with some reason have been thought to point to a Jurassic age, occur in the higher part of the Marine Beds, associated with characteristic Mollusca of undoubted Neocomian type.

During his visit to the Sunday's River district in 1905, Mr. Rogers found additional evidence to show that the whole of the Uitenhage beds there exposed were deposited with comparatively great rapidity. He found that forms which are represented in the strata by abundant individuals occur much more generally distributed throughout the whole thickness of beds than was at first suspected. Some of the most typical species of the marine facies (for instance, the familiar *Trigonia*) were observed to occur, together with layers of lignite, at the very base of the Sunday's River Beds, where Mr. Rogers had expected to find forms characteristic of the Wood Bed facies. These marine forms occur also 300 feet higher in the series, and since the lower beds of the series were seen to be assuming, in some degree, the aspect of the Wood Bed development, the discovery of the familiar marine forms in them occasioned some surprise. Mr. Rogers noted the occurrence of *Hamites* near the mouth of the river, where Stow obtained it at first, but he also found it high up the river in a rock which showed resemblance to the strata of the Wood Bed series. He concludes from his observations during this second survey, that Stow must have been led through insufficient collecting to assign a too restricted vertical distribution to various species. Mr. Rogers believes that from the same cause his own records are likely to prove faulty, and that exhaustive collecting would still more fully demonstrate the extensive vertical distribution of many of the forms throughout the beds exposed.\*

The above considerations lend great support to the results of a comparative study of the fauna, namely, that no forms are known to occur in these beds which give definite indications of the presence of more than the equivalent of a single palæontological stage. Allowing, then, that the cephalopods, supported in no small degree

\* For the published account of the 1905 survey, consult Rogers (2), pp. 15-33.

by the lamellibranchs, afford satisfactory data for a comparison with European standards, we may safely conclude that no portion of the Uitenhage Series represents a period of time earlier or later than the Neocomian. It must be said, indeed, that the almost entire restriction of *Holcostephanus*, sensu stricto (= *Astieria* Auctorum), to the upper part of the Valanginian and lower beds of the Hauterivian in Europe \* suggests much narrower limits, when we consider how important a place is taken by members of this genus in characterising the cephalopod-fauna of the Uitenhage beds.

Leaving, now, the consideration of evidence which leads to these conclusions, we may proceed to compare the Uitenhage fauna with those occurrences in extra-European regions which, in greater or less degree, bear the imprint of a similar facies.

### III.—COMPARISON WITH EXTRA-EUROPEAN FAUNAS.

(a) *Possible Traces of a Related Fauna in the South-west of Madagascar.*—Douvillé has drawn attention to the occurrence of some lamellibranchs obtained by Lieutenant Boutonnet from deposits situated in the Fiherenga Valley, in the basin of the Isakondry River, east of Tullear.† Mention is made of a large *Trigonia*, said to be analogous to some of the *Trigonia* of the Oomia beds in Cutch and of the Uitenhage Series, and with this is associated a shell referred by Douvillé to the genus *Pycnodonta*, and said by him to be closely comparable with *Exogyra imbricata* Krauss (also referred to *Pycnodonta* by Prof. Douvillé). On the evidence of these fossils, the strata containing them are considered by Douvillé to be of Cretaceous age, and Lemoine classes them provisionally as Lower Cretaceous. The account of these fossils so far published is unfortunately meagre, and it must here suffice to have drawn attention to the occurrence of forms in Madagascar which may possibly indicate the presence of a fauna of Uitenhage character.

(b) *Comparison with the Fauna of the Oomia Group in Cutch.*—Striking data for correlation are to be found among the lamellibranchs which constitute so large a part of the Uitenhage fauna, and it becomes apparent that some of the conspicuous elements which help to lend a definite character to the assemblage, while finding no exact parallel in the European area, have an unmistakable counterpart in the fauna of the Oomia *Trigonia*-beds. This

\* In North Germany, for instance, the restriction of these forms to such narrow limits is well marked. See von Koenen (3), pp. 4, 8, 9.

† Douvillé (2), p. 388; Douvillé (4), p. 215; Lemoine (1), p. 176.



agreement is the more remarkable from the fact that in seeking additional data for comparative study among the cephalopods of the Oomia beds, the indications of community furnished by the lamelli-branches are found to obtain no positive support. The cephalopods described by Waagen\* from the Oomia Group, with the exception of the belemnites, do not comprise representatives of any of the genera obtained from the Uitenhage beds, and moreover, when brought into comparison with European forms, seemed to Waagen to indicate a Tithonian or Portlandian age.

Stoliczka† first directed attention to the great similarity between a *Trigonia* collected by Wynne during the geological survey of Cutch,‡ and the South African *T. ventricosa* (Krauss), and the identity of these was afterwards confirmed when the Oomia shell was definitely referred to *T. ventricosa* by Waagen,§ Feistmantel,|| and W. T. Blanford.¶ Feistmantel, in 1876,\*\* noted the close similarity between *Trigonia herzogi* from the Uitenhage beds and a *Trigonia* from the Oomia Group which I have recently described under the name *T. mamillata*. As already pointed out, *T. mamillata* is comparable with *T. herzogi* and the South American *T. transitoria* in the manner in which it exhibits characters somewhat intermediate between those of the Clavellatæ and the Quadratæ, but it bears a still closer resemblance to *T. holubi* sp. nov. Owing to their large and massive shells, and their well-characterised sculptural plan, the members of this group of *Trigonia* form a prominent feature in the faunas in which they occur, and supply significant data in the present comparative study.

The basis for comparison is further strengthened by the association of true Costatæ with members of the Scabræ, both in the Oomia and the Uitenhage strata—a fact to which I have already referred. *T. parva* accompanies *T. ventricosa* in Cutch, and although *T. tenuis*, another costate form, has not been recorded from any of the localities where *T. ventricosa* is found, it occurs in beds at least not older than those from which the remaining Oomia *Trigonia* have been obtained. In the Uitenhage Series we have *T. tatei*, which, although not closely comparable with *T. tenuis*, and distinguished by much coarser ribbing of the flanks, also shares some of the characteristics by which the Oomia form is contrasted with most of the

\* Waagen (1).

† Stoliczka (2), p. 315 (1871).

‡ Wynne (1), pp. 225, 231.

§ Waagen (1), p. 237.

|| Feistmantel (2), p. 164; (3), p. xxxvii.

¶ Medlicott and Blanford (1), p. 261; (2), p. 224. See also Kitchin (1), p. 104.

\*\* Feistmantel (1), p. 116.

Costatæ from the Jurassic rocks of Europe. These distinguishing features are the elongated oval figure, the delicate sculpture of the marginal carina and area, and the elongated form and fine ornamentation of the escutcheon; they lend an aspect of similarity which cannot be overlooked, especially when these lingering examples of a typically Jurassic section are brought into comparison with the majority of European representatives.

Other *Trigoniæ* which serve in most conspicuous manner to characterise the faunas under consideration, and certainly at first sight appear to furnish the strongest corroborative data in a correlation, are the members of the group of *Trigonia v-scripta* in the Oomia beds and the group of *T. vau* in the Uitenhage Formation. The similarity of one of the Oomia *Trigoniæ* to *T. vau* Sharpe seems to have been first pointed out by Feistmantel,\* and W. T. Blanford† shortly afterwards suggested that a shell from the Oomia Group, which was ascribed by Feistmantel to the genus *Goniomya*, might in reality represent the African *T. vau*. Which of three Oomia forms was here and elsewhere‡ referred to in this connection is uncertain, but it is possibly the one which I have described under the name *T. v-scripta*,§ although the less well-known *T. dubia* in reality bears a much closer resemblance to *T. vau*, particularly in the outline. When dealing with the Oomia *Trigoniæ* I pointed out that *T. v-scripta*, when adult, more closely approaches an undescribed Uitenhage form which is associated with *T. vau*. This is *T. stowi*, described in these pages, and it is certainly closely allied to *T. vau*; the youthful characters of shape and ornament are practically identical in these two types, but a marked divergence is observed to accompany progressive growth, and the adult forms are perfectly distinct. The characters of the youthful period in *T. v-scripta* are also practically the same as in *T. recurva*, with which it is associated in the Oomia beds, and in this case likewise, wide divergence is exhibited as the adult characters are required. But the marked differences which exist between the essential features in the youthful stage of the two Uitenhage and the two Oomia shells respectively induced me, when describing the Cutch *Trigoniæ*, to distinguish between the "Group of *T. vau*" and the "Group of *T. v-scripta*." Subsequent examination of further material has strengthened the belief that we are here dealing with a case of convergent development, and that close alliance is by no means to be inferred from the

\* Feistmantel (1), p. 116.

† W. T. Blanford (1), p. 118.

‡ Medlicott and Blanford (1), p. 261.

§ Kitchin (1), p. 70, pls. vii., figs. 6-8; viii., figs. 1-3.



similarity in the adult stage in members of these two groups, however peculiar and striking may be the characters which appear to unite them, and at the same time to differentiate them from all other sections of the genus with which we are acquainted. Since the members of these two groups appear to illustrate mere homœomorphs, their value as evidence in the correlation of the faunas becomes very much reduced, and if dissociated from the forms which accompany them, they could not well be considered to afford proof of contemporaneity. But whatever be the causes that determine the evolution along converging lines in shells which, by their youthful characters, betray a heterogenetic origin, we may in this case safely infer from their occurrence with an association of forms in so many respects similar, that they acquired their common characters at approximately the same time.

Before concluding this comparison of the Uitenhage and Oomia *Trigonia*, attention may be directed to certain broad features of general habit which in some measure lend a distinctive aspect to several members of the genus in the faunas under discussion; and it will be noticed that while these features serve in great degree to imprint a facies on the assemblage which brings it into contrast with European occurrences, the same broad distinguishing characters are not confined to one section of the genus, but are shared by members of stocks not intimately related. There is the tendency to great posterior elongation of the shells, and in some cases a siphonal gape; the obliteration of the carinæ with disappearance of a definite demarcation between flank, area, and escutcheon; the dwindling and disappearance of sculpture on the area; and in several instances the situation of the umbones relatively far from the anterior extremity. In the Oomia beds these points are illustrated in varying degree in certain degenerate derivatives of *Costata*, and in the group of *T. v-scripta*; in the Uitenhage beds they are exemplified in *T. van*, *T. stowi*, *T. rogersi*, and *T. conocardiformis*. In both *Trigonia van* and *T. dubia* the parallelism with the genus *Goniomya* cannot be overlooked, and I have previously suggested that if complete shells of these could be procured, they would be found to gape at the siphonal end; this idea is now supported by a specimen of *T. stowi* sent to me from the South African Museum, which is almost uninjured at the siphonal border, and which plainly exhibits a gaping habit.

We do not find further aids to comparison amongst the few Oomia Mollusca which have already been described, and a detailed account of the remaining lamellibranchs collected by Wynne and Stoliczka

from these beds is still in course of preparation; but I am indebted to the Director of the Geological Survey of India for permission to utilise the Indian specimens at present in my keeping for the purpose of this correlation. Several Oomia types at once suggest most strongly their affinity to Uitenhage forms, and these are the following. An *Exogyra* occurring in Oomia beds at the Trummo River is certainly not distinguishable from individuals of *E. imbricata* Krauss, and may at any rate be thus provisionally named; an *Astarte* found in association with *Trigonia ventricosa* and other characteristic Oomia forms very closely resembles *Astarte herzogi* Krauss, though it is not identical with it; there are fragments of a large, coarsely-ribbed *Cucullæa* which, so far as can be seen, shares all the distinguishing features of the strongly characterised *Cucullæa kraussi* Tate; a large *Gervillia* very closely resembles *G. dentata* Krauss, and is probably identical with it;\* and lastly, the Oomia beds have yielded specimens referable to the genus *Seebachia*, otherwise only known by *Seebachia bronni* (Krauss), from the Uitenhage Series. Two of these individuals from Cutch very closely resemble *S. bronni*, and it is not improbable that they are identical with it.

The closely similar character of these lamellibranch-faunas is clearly shown when we place side by side the identical, proximate, and analogous types, as follows:—

Uitenhage Beds.	Oomia Beds.
<i>Exogyra imbricata</i>	<i>Exogyra imbricata</i>
<i>Cucullæa kraussi</i>	<i>Cucullæa kraussi</i>
<i>Gervillia dentata</i>	<i>Gervillia dentata</i> ?
<i>Astarte herzogi</i>	<i>Astarte</i> sp., near <i>herzogi</i>
<i>Trigonia ventricosa</i>	<i>Trigonia ventricosa</i>
<i>Trigonia holubi</i>	} (Pseudo-quadrata) <i>Trigonia mamillata</i>
<i>Trigonia herzogi</i>	
<i>Trigonia</i> of the <i>vau</i>	<i>Trigonia</i> of the <i>v-scripta</i>
group	group
<i>Seebachia bronni</i>	<i>Seebachia bronni</i> ?

A more critical and detailed study of the Oomia lamellibranchs may possibly reveal further connecting links, but two inferences may already safely be drawn from the general agreement observed to exist between these geographically widely separated faunas. Firstly, despite the absence of clues to correlation derivable from the Cephalopoda, we may conclude that the faunas were approximately con-

\* See also W. T. Blanford (1), p. 118.



temporaneous; and secondly, that the lines of intercourse between the two areas were probably much more direct than was formerly believed to be the case.

This correlation appears therefore to be in conflict with Waagen's conclusions concerning the age of the marine Oomia beds, which were thought to be Portlandian, but a brief consideration will show that this difficulty is more apparent than real. Doubts might perhaps be expressed as to the validity of a comparison based solely upon lamellibranch types, and it must be admitted that in many similar cases it would be right to place greater confidence in the evidence of cephalopods; but in the present instance the lamellibranchs compared are peculiarly well characterised, and indeed comprise no single form known in the European area. On the soundness of the evidence which these well-marked types afford, and upon which the above conclusions are founded, I think no doubt can reasonably be cast.

The Mollusca of the marine Oomia beds, shown by Stoliczka to occur in the lower part of the group, cannot be said to give such definite indications of geological age as are to be derived from a study of the Uitenhage fauna. The ammonites from these lower Oomia beds were considered by Waagen to show close affinity with Upper Jurassic forms in Europe, and he believed some of the *Trigonia* to corroborate fully his view concerning the Portlandian age.\* But a detailed study of the *Trigonia* has shown that this belief was not well founded, and the relationship of any of the Oomia forms to the Portlandian Gibbosæ is at the best a matter for conjecture. I have provisionally referred one of these *Trigonia* to the group Gibbosæ on the strength of a certain broad similarity of characters, while at the same time recognising the possibility that this form may represent an aberrant derivative of some costate stock. Judged by analogy with *Trigonia retrorsa*, which can only be regarded as a degenerate costate type, the relationship of *T. spissicostata* to the Gibbosæ is extremely doubtful, but nothing more definite on this point can be said until material can be collected in a sufficiently favourable state of preservation to throw light on the nature of the youthful stage. Other Oomia *Trigonia* which exhibit characters simulating those of the Portlandian Gibbosæ have been shown to be allied to the section Costatæ, and nothing quite comparable with these diversely modified derivatives is known in Jurassic rocks, though the late adult stage of *T. peninsularis* Coq., from the Aptian of Spain, shows an analogous obliteration of sectional features which was regarded by Lycett to indicate degeneracy. The

\* Waagen (1), p. 233 (1875).

value of *Trigonia mamillata* as an indication for age has already been considered, and the supposition of the Cretaceous rather than the Jurassic affinities of this form receives emphatic support from the presence of *Trigonia ventricosa* and *T. pulchra*, both members of the section *Scabræ*. Though claiming corroboration of his views from *Trigonia* which he supposed to be related to Portlandian forms, Waagen did not state that these were found in actual association with his *Oomia* ammonites; and the fact that none of the critical ammonite-species upon which he relied in his correlation is recorded from any of the localities—such as Goonaree, *Oomia*, or Huroora,—where the *Trigonia*-beds are well developed, gives room for the suggestion that the ammonites and lamellibranchs may not represent horizons of quite the same geological age. Further, if we examine Waagen's descriptions and figures of the four ammonites which were thought to represent European forms, it may perhaps be allowed that too much reliance has been placed on the evidence they were supposed to afford. Two were referred only with doubt to the respective European species; of the remainder, one represents a type of *Perisphinctes* which, so far as can be judged from the description and figure, does not justify the definite conclusions drawn by Waagen concerning its relation to a European Portlandian form. The other, a single specimen referred to the Tithonian *Perisphinctes eudichotomus* Zittel, is so preserved that the lobe-line is not visible, and a comparison of Waagen's figure with Zittel's original specimen in the Palæontological Collection of the State at Munich shows that the Indian form is rather thicker and more involute, though the agreement is otherwise good.

It is scarcely necessary to dwell at any length on the question of the alleged discrepancy between the evidence of the plant and animal remains in settling the age of the *Oomia* beds, since this matter has already been so fully dealt with. The plants of the *Oomia* group were obtained from strata for the most part above the marine beds which yielded the cephalopods and lamellibranchs, but they led Feistmantel to refer these beds to the Middle Jurassic. Even should a revision of the *Oomia* plants prove the correctness of Feistmantel's view that the flora exhibits Oolitic affinities, there are many reasons why the evidence of the marine fauna must be allowed to outweigh that of the plants in a correlation with European stratigraphical standards.\*

Putting on one side the ammonites, the exact bearings of which on this question are somewhat doubtful, it may be said that there is

\* W. T. Blanford (2).



nothing in the fauna of the Oomia *Trigonia*-beds to contradict the results reached by a study of the Uitenhage Mollusca, and a consideration of all the available evidence seems to justify the conclusion that here also we are dealing with the part equivalent of the Neocomian in Europe.

(c) *Traces of a Related Fauna in the Godavari District and in Hazara.*—Traces of the Uitenhage-Oomia lamellibranch-fauna, as principally indicated by the presence of *Trigonia ventricosa*, have also been found to occur in an outlier of the Tripetty beds about 24 miles north-east of Coconada near the south-east coast of the peninsula of India.\* *Trigonia ventricosa* is said to be here accompanied by *Trigonia smeei*, a characteristic fossil of the Oomia Group in Cutch, though it seems possible that this may be *T. crassa*, an Oomia form of similar type.† The small collection of fossils from near Coconada was examined and named by Stoliczka, and it comprises *Inoceramus* and a few other lamellibranchs as well as *Helicoceras* and other remains of cephalopods.

*Trigonia ventricosa* has also been recorded from strata exposed in the Margalla Pass in Hazara (N.-W. Himalayas), where it is said to be found in profusion.‡ The bearings of these occurrences in a discussion of the broad question of distribution will be considered below.

(d) *Neocomian in German East Africa.*—The Lower Cretaceous fossils collected during W. Bornhardt's journeys in German East Africa (1895–1897), and described by G. Müller,§ are of special interest in the present connection, because they exhibit in some measure a Uitenhage facies and also furnish strong links with the molluscan fauna of the Oomia Group. The remains of Cephalopoda are unfortunately very scanty and again fail us as a basis of comparison, but important links are found in some of the lamellibranchs, which include well-characterised *Trigoniæ*. Foremost amongst these is *Trigonia ventricosa*, occurring at a locality 8 km. north of the Nkundi stream, 29 km. north-west of Kiswere, in strata ascribed to the Lower Neocomian and brought into correlation with the Uitenhage beds by Dr. Müller. *Trigonia beyschlagi* G. Müller, which here accompanies *T. ventricosa* in great abundance, appears to have no counterpart in the Uitenhage beds, but it clearly belongs to the same category of modified Costatæ as *T. smeei*|| and *T. crassa*¶ from the

\* King (1), p. 229; Feistmantel (2), p. 164; Feistmantel (3), p. xxxvii.

† Kitchin (1), pp. 42, 43.

‡ Wynne (2), p. 125; Medlicott and Blanford (1), p. 503.

§ G. Müller (1).

|| J. de C. Sowerby (3), pl. lxi., fig. 5.

¶ Kitchin (1), p. 44; pl. iv., figs. 4–6, pl. v., figs. 1–3.

Oomia beds in Cutch; the resemblance to *T. crassa* is indeed very striking, though I have elsewhere stated reasons why these two forms cannot be considered identical.\* But *T. beyschlagi* is certainly either closely related to *T. crassa* or illustrates a stage of removal from the normal ancestral costate plan, on some parallel line, quite comparable with that exemplified by the Oomia form. It was probably in consequence of insufficient acquaintance with *Trigonia smeei* that Müller failed to recognise the true relationships of this peculiar shell; the points of similarity to the Uitenhage shell *Seebachia bronni* (Krauss), to which he called attention, are merely superficial, involving the general outward habit only. Uhlig† has expressed the opinion, however, that the grounds for the generic separation of these two forms are hardly convincing; but he can scarcely have compared the figure showing the dentition of the right valve of *Trigonia beyschlagi*‡ with Neumayr's excellent corresponding illustration of *Seebachia*.§ A glance at these figures proves beyond question that Müller was right in assigning his shell to the genus *Trigonia*, and now it is interesting to find the clue to its narrower relationships by a comparison with the Oomia forms, a detailed account of which had not appeared at the time when Müller wrote.

Amongst the fossils collected at a locality in the district of Ntandi, 35 km. west of Mtshinga, which Müller considered to indicate a Middle Neocomian horizon, a large *Gervillia*, apparently identical with *G. dentata* Krauss, serves as a connecting link to both the Uitenhage and Oomia faunas. There is also a *Ptychomya* (*Ptychomya hauchecornei* Müll.) which, though distinct from *P. complicata* (Tate), may possibly be nearly related to it. *Trigonia bornhardti* Müller, from the same locality, is only so far comparable with the Uitenhage-Oomia *Trigoniae*, that in common with some of these it exhibits a marked posterior elongation, with absence of sculpture from the area and the posterior part of the flank in the adult shell, in which also the area has ceased to be demarcated from the flank. An *Astarte* from the Oomia *Trigonia*-beds compares very closely with the shells from Ntandi described by Müller under the name *Eriphyla stuhlmanni*, particularly in the character of the hinge and the very deep lunule, though it differs somewhat in the outline and ornamentation; *Astarte herzogi* from the Uitenhage beds also belongs to the same division of the genus.

\* Kitchen (1), p. 121.

† Uhlig (3).

‡ G. Müller (1), pl. xix., fig. 3.

§ Holub and Neumayr (1), pl. ii., fig. 4b.



Still greater interest attaches to a *Trigonia* which strongly recalls the peculiar types belonging to the group of *T. v-scripta* in the Oomia *Trigonia* beds and the Uitenhage group of *T. vau*. This is *T. kühni* Müll., found in strata ascribed to the Upper Neocomian at a locality 23 km. west-south-west of Mtshinga, and it possesses characters which appear to indicate relationship to one of the groups mentioned rather than to the members of other groups with which Dr. Müller has also brought it into comparison. *Trigonia kühni*, it is true, seems to be distinguished from *T. vau* as well as from *T. v-scripta* and its allies both by its less equilateral form and the persistent ornaments of its escutcheon; but to judge from the description, and especially from the figure of an imperfect specimen\* which shows the convexity of the anterior profile and the crowded ribs of the frontal series obliquely crossing the growth lines—just as in the Oomia *T. recurva*—there can be little doubt about the position of this shell relative to the main divisions of the genus. Whether it is more closely allied to the group of *T. v-scripta* or to *T. vau* and *T. stowi* sp. nov., cannot be ascertained until more perfect specimens can be obtained and the sculpture of the youthful growth-stage examined.

Of less significance, perhaps, is the occurrence of *Pecten striato-punctatus* Roem., which was found with *Gervillia dentata*, and *Arca uitenhagensis* Müller, which accompanies *Trigonia beyschlagi*. They may be brought into near comparison with *Pecten projectus* Tate and *Arca jonesi* Tate, though little importance could be attached to such types as these, if taken alone. Another *Pecten*, from the same locality as that from which *P. striato-punctatus* was obtained, was considered by Müller to represent very probably *P. cottaldinus* d'Orb., which also occurs in the Uitenhage beds. The relationship of the Oomia fauna to that described from German East Africa is of course what we might expect to find, having regard to the manner in which a close connection between the Upper Jurassic faunas of East Africa and Cutch has been demonstrated by those who have studied the Cephalopoda.

Enough has been said to indicate the position taken by these East African occurrences in a widely distributed Neocomian fauna of southern type, and to show that such connecting links as are available, no less than the general aspect which the fauna, wherever it is developed, derives from the prevalence of peculiarly characterised *Trigonia*, plainly serve to unite the molluscan assemblages of these three remotely separated districts in the eastern hemisphere.

\* G. Müller (1), Taf. xxv., fig. 8.

Some indications of a western extension of the same type of fauna are to be recognised on the South American continent.

(e) *Neocomian in South America*.—Amongst the fossils collected in 1899 by the late J. B. Hatcher from the Pueyrrydon Series in Patagonia\* are several lamellibranchs of distinctive type which permit of close comparison with some of those above discussed. They have been described and figured by Stanton,† who was led to ascribe a Lower Cretaceous age to the Pueyrrydon Series, though he was unable to establish a narrower correlation with the formations of other regions. The most striking resemblances to Uitenhage forms are seen in two *Trigonia* from the Belgrano beds, *T. subventricosa* Stanton, a member of the section Scabræ, and *T. heterosculpta* Stanton, believed by Stanton to be allied to *T. vau* Sharpe. *Trigonia subventricosa* certainly approaches very closely to *T. ventricosa*, particularly in the wide spacing and robustness of the anterior varices. The differences in the sculpture pointed out by Dr. Stanton appear to be less emphasised when this Patagonian form is brought into comparison with the large and more coarsely ornamented *T. kraussi* sp. nov., which occurs with *T. ventricosa*. But if the relations of height to length exhibited by the figured specimen of *T. subventricosa* be those which characterise the average shells of that form, then there is good ground for the separation of these three members of the Scabræ, which at the same time appear to be united by similar broad features of peculiar form and ornament. They are the only known examples of this particular extreme type, and probably represent a group in this southern development parallel with that of which *T. scabricola* Lycett and *T. aliformis* Park. are typical members in Europe.

The ornamentation of *T. heterosculpta* is of such a kind as to recall instantly the conspicuous shells of the groups of *T. v-scripta* and *T. vau*. The principal points of resemblance are the manner in which steeply inclined ribs of two series on the flank meet to form an angular pattern, and the absence of sculpture from the area and the posterior portion of the flank in the adult shell. *T. heterosculpta* is certainly not to be brought into comparison with the European *Undulata*, but its whole aspect suggests a close connection with the group of *T. vau*. Its near relationship to *T. vau* and *T. stowi* is clearly to be inferred from a comparison of the youthful characters, which are very similar, and affinity with these rather than with the Indian group of *T. v-scripta* is exactly what we might expect to find, having regard to the geographical relationships. The adult

\* Hatcher (1).

† Stanton (3).



*T. heterosculpta* differs, however, from its African allies by the less posterior elongation of the shell.

Here again, in the Belgrano beds, we find an associated *Gervillia* of large dimensions, which does not appear to be widely removed from *G. dentata* Krauss, while a large *Astarte* (*A. perlata* Stanton) with short and deeply excavated lunule, may be said to have its parallel in the Oomia beds of Cutch, if we confine the comparison to broad outward features. At a somewhat lower horizon in the Pueyrrydon Series (the Gio beds) *Ostrea tardensis* Stanton, which occurs abundantly, represents a type of *Ostrea* or *Exogyra* which has much in common with *Exogyra imbricata* Krauss; and to judge from the description of *O. tardensis*, it seems likely that these two forms may really be very closely comparable. A special value cannot, of course, be attached to the comparison of such types as these if studied alone, but the resemblance gains significance when viewed in connection with the other Mollusca above discussed. It will be seen therefore, that although the basis of comparison is somewhat slender, yet the occurrences above noted in no slight measure suggest the closest alliance with the molluscan fauna of the South African Neocomian; and it may be added that there is nothing in the Pueyrrydon fauna itself to contradict the assumption that we are dealing with a western part-equivalent of the Uitenhage development.

A search for further traces of the characterising elements of the Uitenhage fauna in the Lower Cretaceous deposits of South America reveals evidences of a very suggestive description. The Lower Cretaceous beds in Bolivia and Chili which have yielded *Trigonia transitoria* Steinmann\* are probably of similar age and seem to represent the more northerly equivalents or part-equivalents of the Pueyrrydon Series. *Trigonia transitoria* has also been found to occur abundantly at the Arroyo Triuguico and at Quili Malal in the Argentine Republic, in strata ascribed by Behrendsen† to the Neocomian. It occurs, moreover, with significant associates in the *Trigonia*-beds of Lower Neocomian age exposed on the left bank of the Rio Agrio, opposite to Las Lajas (Argentine Republic);‡ these beds yield another member of the Pseudo-quadratae (*T. neuquensis* Burckhardt) and a *Trigonia* very closely resembling the South African *T. conocardiiformis*,§ as well as an *Eriphyla* in some respects comparable with the South African *Astarte* (*Eryphyla*)

\* Steinmann (1), p. 260; Steinmann (3); R. A. Philippi (1), p. 63; Paulcke (1), p. 297.

† Behrendsen (1), p. 25.

‡ Burckhardt (1), p. 21.

§ Burckhardt (2), pp. 72-75, 111, 112.

*herzogi*. Dr. Stanton has suggested that a *Trigonia* quoted by Behrendsen\* as "*Trigonia* cf. *aliformis* Park." from supposed Upper Neocomian beds at the Arroyo Pequenco may possibly be identical with the Patagonian *T. subventricosa*. It is accompanied by an oyster which Behrendsen identified with *Exogyra couloni*, and found to agree well with the figures of *Ostrea couloni* cited by Bayle and Coquand† from the Neocomian at Arqueros in Chili. The Chilian shells ascribed to *O. couloni* bear a considerable resemblance to the Uitenhage *Exogyra imbricata* Krauss, with which Coquand even later identified them,‡ and accompanying this oyster in Chili is *Trigonia delafosse* Bayle and Coquand, the resemblance of which to *T. ventricosa* has been elsewhere remarked upon.§ Associated with these forms is a *Crioceras* identified by Bayle and Coquand with the European *C. duvali* Lév., thus recalling the analogous association of *Trigonia ventricosa*, *Crioceras spinosissimum* and *Exogyra imbricata* in South Africa. Of the above-mentioned Mollusca, *Trigonia delafosse*, *T. transitoria*, *T. neuquensis*, and *T. cf. conocardiiformis* suggest very strongly their relationship to Uitenhage and Oomia forms. It should be noted also that Philippi has described *Trigonia* from localities in Chili, which share the characters of peculiar sculpture and siphonal elongation shown by the group of *T. van Sharpe*, while *T. eximia* R. A. Philippi, from the Tinguirica valley in Chili, appears to be closely related to *T. conocardiiformis* (Krauss) and Burckhardt's *T. cf. conocardiiformis*.

#### IV.—THE DISTRIBUTION OF THE UITENHAGE FAUNA IN RELATION TO SOME THEORETICAL QUESTIONS.

We may now briefly consider in what measure the correlation of the Uitenhage Neocomian fauna with the similar assemblages in German East Africa and in Cutch bears upon the theory of an Indo-African land barrier during early Cretaceous times; and further, we may inquire how far the facts concerning the dispersal of these Mollusca have significance in relation to Neumayr's theory of distribution according to climatic zones, as deduced from a study of the Cephalopoda. The one question is in reality largely bound up with the other, and since in both cases the inquiry is of a so purely palæontological character, it may be of advantage briefly to review the evidence now available. Moreover, it is advisable to glance at

\* Behrendsen (1), p. 418.

† Bayle and Coquand (1), p. 37.

‡ Coquand (2), p. 158.

§ Lycett (3), p. 120 (1875); Kitchin (1), p. 108; Pauleke (1), p. 296.



these aspects of the distribution as now known to us, because Neumayr himself attached very great importance to the testimony of the Uitenhage fauna in supporting both the above theories. But at that time it was not known that the links connecting the bivalve-faunas of the Uitenhage and Oomia strata were so numerous or complete as they are now proved to be, while the existence of a related molluscan assemblage in German East Africa was unsuspected.

Although Neumayr was led to the theory of a great equatorial enclosed sea ("Ethiopian Mediterranean") chiefly by a comparative study of faunas of essentially Jurassic character, yet he felt justified in utilising the Uitenhage fauna also as an aid in this palæogeographic reconstruction.\* He believed that the radical differences between the Mollusca of these beds and the more northerly East African occurrences of Upper Jurassic age were an indication that the faunas had for some time lived in distinct areas separated by a land barrier, and from this he thought to derive support for a theory the truth of which had seemed to be attested by evidence of a different character.† In spite of weighty opposition,‡ this theory of a land connection extending from the Indian peninsula through Madagascar to South Africa at the beginning of Cretaceous times has continued to find favour, and it is only comparatively recently that the significance of the palæontological evidence has again been called in question. In view of the presence of some traces of the Uitenhage fauna in the Godavari district and also in Cutch and Hazara, Neumayr supposed that a connection between the equatorial and southern waters must have existed in the form of a strait, the situation of which he believed to be most probably about the present Gangetic plain. The late Dr. W. T. Blanford held a similar view; § he summarised the main arguments in favour of the theory, suggesting that a shallow water connection near India,—situated very possibly to the eastwards, though not precisely as Neumayr supposed,—would account for the northerly dispersal, and that if this were later converted into land, the "progressive diminution of European species in the three stages of the S. Indian Cretaceous beds would be explained by the increasing effect of isolation." Professor Suess also speaks of these traces of the Uitenhage fauna in Cutch and in the Salt Range as possible indications of an

\* Neumayr (3); Neumayr (6), pp. 259, 261, 295, 296, 529.

† Stow (1), p. 546; H. F. Blanford (1), pp. 534-540; Medicott and Blanford (1), pp. xxxix., lxviii., lxxii., 297.

‡ Wallace (1), pp. 422-427.

§ W. T. Blanford (3), pp. 98, 99.

encroachment of the southern development into the northern region.\* With reference to the same subject, Mr. R. D. Oldham wrote: "This barrier does not seem to have been absolutely continuous throughout the jurassic period, or there may have been a mode of communication round the north of the Peninsula of India by which some migration took place, and so the presence of a few Cutch species, which are also found on the east coast of India and in South Africa, is accounted for." †

The belief in this supposed land mass extending through Madagascar and cutting off an equatorial basin from the colder southern ocean, has been thought to receive the strongest support from a comparison of some belemnites of Neocomian age found at localities in the north-west of Madagascar.‡ Neumayr found that while these belemnites belong to groups which in their distribution are essentially associated with the equatorial and South European development, the single belemnite (*B. africanus* Tate) then known from the Uitenhage beds is not closely comparable with any of these, but belongs to a group distributed in the northern hemisphere only in the boreal region and in the northern part of the temperate zone.§ From this he drew the conclusion that these representatives of contrasted groups of belemnites belong to faunas of radically different type, which flourished in separate geographical regions. Much has been made of this piece of evidence, which, so far as it goes, is admittedly very suggestive. The late Dr. W. T. Blanford || more recently drew attention to some independent evidence of another kind which indirectly lends support to the theory of an Indo-African land barrier in pre-Tertiary times, but this only bears on the general question of the existence of a barrier, without any possible reference to its state of completeness during any part of the Cretaceous period. Dr. F. Kossmat ¶ has shown that so far as the distribution of the faunas of Ariyalur (Senonian) age was known at the time when he wrote, the evidence was in favour of a barrier separating the waters of the Mediterranean province (with its easterly extension) from the South Indian ocean. He concluded from a careful comparative study of the Cephalopoda that the fauna represented in the Trichinopoly-Pondicherry districts had intercourse with the European area only by way of Natal and to the west.

The distribution of the much older Uitenhage fauna must certainly

\* Suess (1), p. 536.

† Newton (1), p. 333.

|| W. T. Blanford (4).

‡ In Medlicott and Blanford (2), p. 211.

§ Neumayr (5).

¶ Kossmat (1), Kossmat (2).



lead us to a somewhat different conclusion concerning the relation of the equatorial and the southern ocean at that period. In order to form an approximately correct picture, we must at least compare faunas of similar age, for it is probable that migration from one area into another may take place exceedingly rapidly when measured by geological standards, and that a fauna may thus become quickly modified as regards some of its most salient characteristics. Dr. Kossmat has brought forward evidence to show that in the migration of Upper Cretaceous cephalopods "the distribution of the species did not require any geologically measurable time."\* In contrasting the Uitenhage fauna with any occurrences on the western shore of his equatorial sea, Neumayr was not able to compare with contemporaneous faunas, except perhaps that of the Belemnite-beds in the north-west of Madagascar. But in this case the possible grounds of comparison were of the most slender description, since in the Neocomian of Madagascar the known fauna consisted solely of belemnites; and hence the very hazardous nature of the generalisations which Neumayr was led to make as a result of the comparison. It is very probable that the great contrast between these faunas may owe its strength in no slight measure to differences of local facies, a factor which does not seem to have been sufficiently taken into account;† the Belemnite-beds of Madagascar probably represent deeper water conditions, in contrast to the littoral character exhibited by the Uitenhage molluscs. Moreover, it is easy to conceive that the lines of communication between the two areas were in reality somewhat indirect, without necessarily accepting Neumayr's extreme interpretation of the facts. It may be admitted that the arguments drawn from evidence furnished by distribution at an earlier and a considerably later age decidedly favour the view that in Neocomian times a ridge extended from India to South Africa; this, however, may have been only partially elevated into land, and one or more intervening tracts of shallow water would suffice to allow passage from north to south. Pavlow‡ and Uhlig§ have pointed out the very close affinity between species of *Holcostephanus* from the Uitenhage beds and *H. schenki* (Opp.) from the Spiti Shales, while Kossmat has also remarked on the close relationship between Uitenhage fossils and Lower Neocomian forms in the Salt

\* Kossmat (3), pp. 78-81.

† Since these sentences were written (in 1903), Lemoine has expressed the same opinion; see Lemoine (1), p. 391.

‡ Pavlow and Lamplugh (1), p. 493 (p. 135 of authors' separate copy).

§ Uhlig (4), p. 132.

Range.\* He thinks this cannot readily be explained except by an oceanic connection separating India and Africa. In addition, the question of the existence of very strong palæontological links connecting the Uitenhage fauna with that of the marine Oomia beds in Cutch, concerning which some doubts might at one time have been held, and were, in fact, expressed, may now be considered to have been definitely settled, and this cannot be lightly set on one side. Further, the recent discovery in the Uitenhage beds of belemnites which are related to the Neocomian *Hastati* of Europe, a group represented in the north-west of Madagascar, has undoubted significance, and helps materially to invalidate Neumayr's ingenious argument.

There is, indeed, no evidence that the means of communication lay only by way of the east coast of the Indian peninsula and thence to Cutch, and while the occurrence of *Trigonia ventricosa* near Coconada might seem to suggest that the submergence of the ridge was not so great as to preclude the migration of some littoral types, the discovery of a Neocomian fauna in German East Africa showing relationship to that of the Uitenhage Series, throws some fresh light on the question and appears to require a more direct line of communication. This may most reasonably be supposed to have existed in some nearer passage, situated between Africa and India, as above indicated. The seeming absence of the Uitenhage cephalopods or of the genus *Seebachia* from the Neocomian of German East Africa may very probably be due to our imperfect knowledge of the fauna in this less frequented district. The Cephalopoda of the Uitenhage Series, although perhaps rarer in their occurrence than the lamellibranchs, are well known because these beds have been more thoroughly and more frequently searched than those in German East Africa.

We may here note Dr. G. Müller's suggestion† to the effect that Stow's record of Uitenhage lamellibranchs from the Zambesi,‡ which was discredited by Holub,§ may after all prove to have been authentic. Until this record can be substantiated, however, the suggestion may perhaps be without special significance as pointing to the direction in which a fauna of intermediate character may be sought for. The fact that it is not in the nearer East African Neocomian, but in the more remote Oomia strata that the higher percentage of Uitenhage forms is found to occur, may possibly indicate that the passage between north and

\* Kossmat (3), p. 78, footnote.

† G. Müller (1), p. 571.

‡ Stow (1), p. 505, in editorial footnote.

§ Suess (1), p. 541, note 28.



south was not situated in close proximity to the present African continent. On this point nothing definite can at present be said, and it must be admitted that recent advances in our knowledge of the Mesozoic rocks in Madagascar and on the east coast of Africa can only serve as a warning against premature speculation on such a subject. As regards Jurassic deposits, we now know that, contrary to formerly held belief, these are not confined to the north-west coast region of Madagascar, for strata of Oxfordian age have been shown to be present in the south-west part of the island, in the basin of the River Isakondry, east of Tullear.\* Professor Douvillé considers that in these deposits the contrast in faunistic and lithological facies to the strata of corresponding age in the north-west of the island may be accounted for by different conditions of sedimentation, and is not to be ascribed to deposition in separate basins.† As remarked on a previous page, deposits which may perhaps be equivalent or partly equivalent to the Uitenhage Series, also occur in the Isakondry basin. Prof. Douvillé has given brief notices of the fossils found in these beds by Lieutenant Boutonnet, and has drawn attention to the occurrence here of a large *Trigonia* which, he says, recalls the *Trigonia* of the Oomia beds in Cutch and the Uitenhage beds in South Africa. Associated with this is a shell which closely resembles *Exogyra imbricata* Krauss (referred to by Prof. Douvillé under the generic name *Pycnodonta*).‡ The same region in Madagascar has furnished a Cenomanian fauna which is said to show relations to the corresponding faunas both of Europe and Southern India.§ Concerning the conditions at a later period, the discovery of fossiliferous Senonian deposits at Fanivelona and Marohita on the east coast of Madagascar is very significant. The fossils found on the River Sakaleou, 10 km. from the coast and 30 km. north of Mahela, are stated by Prof. Boule to include forms which show clear relationship to the fauna of Ariyalur type in Southern India and also to the Senonian of Baluchistan.|| Some of Prof. Boule's remarks on this subject are as follows: "Hitherto it has been admitted that the eastern coast of Madagascar is lacking in all sedimentary deposits of the Secondary era, and this belief has played an important rôle in the theories expressed by various scientists; Oldham, Neumayr, Suess, Kossmat, etc., on the former distribution of land and sea and concerning the existence, during the Secondary era, of a continent

\* Boule (2), p. 131.

† Douvillé (3), p. 435.

‡ Douvillé (2), p. 388; Douvillé (4), p. 215; Lemoine (1), p. 176.

§ Boule (1), p. 184.

|| Boule (2), pp. 132, 133.

uniting Africa with India (*Lemuria* of the zoologists). This hypothesis appears to be justified in the case of the Triassic epoch, since there are close relationships, both from the palæontological and stratigraphical point of view, between the deposits of India and of the south of Africa (fauna with dicynodont reptiles; *Glossopteris* flora); but the hypothesis can no longer be applied to the Jurassic epoch, for various reasons which would take too long to enumerate here. As to the Cretaceous epoch, the discovery, on the east coast, of the fossils mentioned above, compels us to admit that our great colony was already an island. The affinities of these fossils with those of the west as well as with those of the east of India support the same conclusion."\* Haug has confirmed the analogies between the Upper Cretaceous faunas of India and Madagascar, but he considers that the discovery of Senonian deposits on the east side of Madagascar does not weaken the hypothesis of an Indo-Malagasy continental mass.† In discussing M. Haug's paper, Prof. Boule maintained that the theory of a land barrier is now very difficult to uphold, and thought that recent discoveries in Madagascar greatly weaken the theory.‡ Again, with M. Thevenin, he has written as follows: "If it has truly existed, the Indo-Malagasy continent must have been reduced then to a long Indian peninsula or to a suite of islands situated on positions where one to-day observes depths of 6,000 metres."§

Turning now to the African mainland, it may be remarked that from the coast, as far south as Delagoa Bay, an Aptian fauna has been described which, while later than the Uitenhage fauna, and consequently not to be closely compared with it, contains cephalopods exhibiting the closest relationship to those of the Aptian with *Acanthoceras martini* in Southern Europe.|| This in itself appears to be sufficient to throw doubt upon the existence of a barrier near the African coast at that period. Further, the recent discoveries of an Upper Cretaceous fauna in Mozambique, showing clear affinities with the Southern Indian development (Utatur and Ariyalur stages),¶ seem quite to disprove the existence of a permanent barrier even at the approach of that later time which we have hitherto thought to furnish the most sure evidences of separation. It is apparent that

\* See also Boule (3); Boule (4), pp. 684, 685; Douvillé (4), p. 215; Boule (5); Boule and Thevenin (1), p. 59; Lemoine (1), p. 232.

† Haug (1), p. 397.

‡ Haug (1), p. 398.

§ Boule and Thevenin (1), p. 59. See also Woods (4), p. 348.

|| Kilian (2); Kilian (3).

¶ Choffat (1); Choffat (2); Choffat (3); Lemoine (1), p. 396.



although the known evidence seems to be on the whole destructive of Neumayr's view regarding the isolation of the Uitenhage fauna, yet any attempt to reconstruct precisely the geographical relations of the region under consideration in early Cretaceous times must still remain purely within the realm of speculation.

One point at any rate is clear, that the argument based upon the sharp contrast between the Neocomian fauna of Cape Colony and comparable occurrences situated on the African continent to the north of the supposed separating ridge, can no longer be utilised. We are now able to compare contemporaneous faunas in which, so far as the lamellibranch element is concerned, the validity of the comparison is not impaired by differences of facies due to local conditions; and the supposed contrast is no longer perceivable. The apparently almost complete restriction of the Uitenhage cephalopods to the southern district in Africa may still seem to require some further explanation, but should scarcely occasion more surprise than the fact that only one species from the Neocomian Belemnite-beds of north-west Madagascar is included in the East African fauna described by Müller, although both inhabited the equatorial waters. As a further example of the risk of making premature deductions from the apparent dispersal of cephalopods, it may be noted that not one of the cephalopod-genera of the Uitenhage area has been recorded from the Pueyrriodon series in Patagonia, although the occurrence of these forms there would be exactly in accord with a distribution regulated by the principles upheld by Neumayr. The evidence of the other Mollusca seems, indeed, to lend every support to the view that a continuous shore-line extended between South Africa and South America, and this idea has gained further justification from the recent work of C. Burckhardt.

This brings us to inquire whether the Uitenhage ammonitoids are in reality so peculiarly restricted in their geographical distribution as at first appears. It is certainly remarkable that no definite traces of them have been found in the African equatorial regions,\* while close allies are known from Western Europe and the Himalayas. Indeed, it may be said that these cephalopods exhibit in the main a distinctly "Middle European" facies, and thus at first sight seem to lend support to Neumayr's distribution theory.† We have seen that amongst the lamellibranchs, leaving out of account

\* A very badly preserved ammonite found at one of the localities visited by Bornhardt has been referred to the genus *Holcostephanus*. Whether this indicates the presence of Uitenhage forms, which appears not improbable, further collecting alone may be expected to decide.

† Neumayr (2).

many apparently cosmopolitan forms, some of the most characteristic and highly specialised types follow a very different distribution. It might perhaps be supposed that members of this class, owing to their relatively passive habit, were more inured to varied environment than the cephalopods, while these, on the other hand, possibly equipped with better facilities for exercising choice of station, were more delicately adjusted to conditions of temperature, food-supply, and other special characters of environment. Nothing, however, is known regarding the exact mode of life of these cephalopod-types; but while the evidence so ably handled by Neumayr seemed for some time inevitably to urge the acceptance of his fascinating theory, a body of facts has since been brought to knowledge which must surely indicate that climatic conditions played at the most an insignificant part in regulating the dispersion of ammonites, and that distribution of land and sea is in reality to be recognised as the most potent determining factor.\* It is therefore scarcely conceivable that in the case of the Uitenhage fauna a distribution of land and sea which permitted the migration of well-characterised lamellibranch-forms over such a wide area, could have offered any obstacles to a similar geographical range for some, at least, of the cephalopod types. It must be remembered, too, that members of the true *Holcostephanus* (Pavlov's *Astieria*) have been described from the Mazapil district in Mexico.†

It becomes plainly apparent that with the limited evidence as yet available, the only reasonable course is to suspend judgment concerning the exact significance of the Uitenhage Cephalopoda in this question of distribution, and a definite pronouncement will only be justifiable when our knowledge of the Indian and African Neocomian faunas is more complete. In view of the facts to which reference has already been made, it is necessary to abandon the supposition that these cephalopods were excluded from the equatorial waters; but in the meantime there is nothing to show whether the absence of these forms from the Neocomian of German East Africa and Cutch is merely apparent,—in which case the fact of their occurrence there may become established by extended search,—or whether it is real, and to be accounted for by causes of a local character. In this connection it is well to bear in mind that in Europe certain Cephalopoda of the Chalk, though living under conditions which might be expected to have assured exceptional uniformity of environ-

\* Kossmat (2), p. 53; Nikitin (2); Burekhardt (2), pp. 115-135; Solger (1), pp. 220-221; G. Boehm (2); Tornquist (1), p. 285; Ortmann (1); Stanton (2) Burekhardt (3), p. 179.

† Burekhardt (3), p. 183-185.



ment, were nevertheless peculiarly local in their occurrence, even within a relatively restricted area. The greater, then, is the necessity for caution in generalising from scanty data regarding the insufficiently explored littoral Neocomian deposits with which we are dealing.

#### V.—DESCRIPTIONS, CRITICAL NOTES, AND LISTS OF FOSSILS.

In the records of occurrence accompanying the following descriptions, it will be understood that when no collector's name is mentioned, and no other indications are given, the specimens in question were obtained by Mr. A. W. Rogers and Mr. E. H. L. Schwarz in 1900 or by Mr. Rogers in 1905. The numbers quoted in parentheses refer to numbers printed on labels affixed to the specimens. All the specimens obtained in 1900 by Messrs. Rogers and Schwarz, and some also sent to me from the collection in the South African Museum, are labelled with plain numbers printed on yellow paper. Those collected in 1905 by Mr. Rogers have blue labels bearing a number followed by an alphabetical letter. A few of the specimens from the South African Museum and all those comprising the collection obtained by Miss M. Wilman at Coega are without numbers.

With the exception of *Holcostephanus baini*, *H. modderensis*, and *H. wilmanæ*, all the fossils fully dealt with in these pages are represented in the collections submitted to me by Mr. Rogers; but it need scarcely be remarked that these only include examples of about two-thirds of the species of invertebrates known to occur in the Uitenhage Series, and it may be added that the published accounts of several types figured or described by Sharpe and Tate call for critical revision at some future time. To deal exhaustively with all the invertebrate forms hitherto recorded from the Uitenhage beds is beyond the scope of this memoir; and since a single compiled list of the whole fauna, including names taken without criticism from other works, would be open to obvious objection, it will be found that lists of species with localities given at the close of this descriptive section, contain names which, except those of the ammonites just mentioned, refer only to specimens entrusted to me by Mr. Rogers. Additional notes of occurrences, however, frequently accompany the following descriptions and comparisons, and are based on specimens preserved in the collection of the Geological Society of London or in the British Museum (Natural History). A few forms not dealt with

in detail below have already been briefly noticed in the second section of this paper, in so far as it seemed necessary to draw attention to their significance in reference to the question of geological age: the names of these, and the remainder of the invertebrate fossils of the Uitenhage Series which have hitherto been recorded, are brought together in the supplementary list and brief accompanying notes with which the present section of this memoir concludes.

In those few instances in which Uitenhage forms are referred to European species, I have refrained from burdening the subjoined accounts with full synonymic lists, but have given a reference to the original description and, where possible, to a recent work in which fuller guidance to the literature of the species may be obtained. Throughout the following pages, however, nomenclatural references are restricted to those works which contain such information as to insure, in my belief, the truly synonymic value of the citations.

In the description of the Gasteropoda a conventional orientation is employed for the sake of clearness, and when use is made of the terms "above" and "below" in this connection it is assumed that the specimen be held with the apex directed vertically upwards. The terms "nepionic" and "neanic," occasionally employed with reference to the young or immature stages in some of the lamelli-branches described below, are so well known and so frequently used as to call for no explanation here.\*

For an account of the available geological information in connection with the occurrence of the specimens obtained in 1900 reference should of course be made to the Report by Messrs. Rogers and Schwarz,† but this may be supplemented by a brief note contained in a letter written to me by Mr. Rogers, to the following effect: "The specimens from Dunbrodie and Blue Cliff are from the lower beds of the Uitenhage Series, those from the Clay Pit near Rawson Bridge from the lowest marine beds in the Zwartkop's River section. Those from the Grass Ridge, Uitenhage, and from the kloofs near Red House and Picnic Bush belong to the highest beds we found, and the specimens from the Graaff-Reinet railway section and those from the main line up-side of Rawson Bridge are from the middle portion of the marine beds." I am informed that the collection obtained at Coega by Miss Wilman was made at a locality on the farm of that name, though outside the river valley, while the label "Coega River" refers to a section in the river valley on the same farm, but probably on a rather lower horizon in the Marine Beds.

\* See Hyatt (1); Jackson (1), p. 293; Buckman and Bather (1); Hyatt (2), p. 94.

† Rogers and Schwarz (1); also Rogers (1), pp. 281-292.



In the case of the specimens from the collection of the South African Museum labelled "Sunday's River," no more detailed account of locality is available, but these are all typical Mollusca of the Marine Beds or Sunday's River Beds. Of all the fossils examined, the only forms which indicate fresh-water conditions are the *Unio* from the Wood Beds of the Bezuidenhouts River, below Blue Cliff station, and a single specimen of *Limnæa* from the section at Buck Kraal, Sunday's River. Whatever may be the exact relation of the fossiliferous beds exposed below Dunbrodie (occurring below a band containing plant impressions) to the main part of the "Wood Bed" series, the fauna from Dunbrodie is essentially a marine one: as already stated in the second section of this paper, there is no reason on palæontological grounds to suppose that this small marine assemblage, characterised by the prevalence of Gasteropoda, is materially older than the fauna yielded by the *Trigonia*-bearing Marine Beds.

The collection obtained by Mr. Rogers from the Marine Beds of the Coega River and Sunday's River valleys, in 1905, includes some interesting additions to the fauna. For full information concerning the occurrence of these and commoner associated forms, the recent report by Mr. Rogers should be consulted.\* This work adds materially to our knowledge of the Sunday's River Beds, particularly with regard to the vertical distribution of many of the Mollusca in the extensive sections examined; but the results in no way strengthen the hope that a scheme of zonal subdivision of the Marine Beds may soon be within reach of attainment. On the contrary, the evidence obtained by Mr. Rogers, as already mentioned, seems to emphasise the striking similarity in the aspect of the fauna throughout the whole thickness of beds exposed.

The few specimens found by Mr. Rogers in a patch of marine Uitenhage beds at Knysna Estuary† only represent the product of a hasty search, and it is believed that careful collecting at this new locality may yield good results.

## CLASS ANTHOZOA.

### GENUS THAMNASTRÆA † Lesauvage.

#### THAMNASTRÆA sp.

There are several specimens of a *Thamnastræa* from the locality between milestones 24½ and 24¾ on the railway between Uitenhage

\* Rogers (2), pp. 22-33.

† Schwarz (2), pp. 50, 74.

‡ For remarks on the correct application of this generic name see Gregory (2), p. 131.

and Graaff-Reinet (345-349). These occur in a hard limestone matrix, and the coral itself is replaced by crystalline carbonate of lime and is in a condition unfavourable for detailed study. The corallum is relatively slender, subcylindrical and branching in form. The calicinal centres are situated at about 2 mm. from one another.

Prof. J. W. Gregory has seen a specimen of this form, and considers that it may be correctly assigned to the genus *Thamnastræa*. In view of the scanty material so far obtained, and its imperfect condition, a fuller description and comparison with described species may be deferred for the present.

## CLASS ANNELIDA.

### GENUS SERPULA Linnaeus.

#### SERPULA cf. CONCAVA (J. Sowerby).

##### Plate II., figs. 1, 1a.

- Cf. 1814. *Vermicularia concava* J. Sowerby, The Mineral Conchology of Great Britain, vol. i., p. 125, Tab. 57, figs. 1-5.  
 „ 1836. *Vermetus concavus* J. de C. Sowerby, Trans. Geol. Soc. Lond., ser. 2, vol. iv., p. 343, pl. xviii., fig. 10.  
 „ 1884. *Vermicularia concava* R. Damon, Geology of Weymouth, Portland and Coast of Dorsetshire, 2nd edition, p. 128, fig. 48.

*Description.*—The tube is wound in the form of a very flat spire, widely umbilicated, with the apical part not projecting above the outside whorl when viewed in lateral profile. The whorls are in close contact, or slightly embracing. The tube is of slightly flattened cylindrical or oval section, the flattening at right angles to the axis of the spire. After the third whorl the tube ceases to be coiled and becomes free. The surface of the tube is marked by numerous irregular transverse wrinkles and furrows.

#### *Dimensions.*—

Greatest diameter across the whorls .....	9 mm.
Greatest external diameter of the tube at the close of the coiled stage .....	3 „

*Occurrence.*—A single specimen was found between milestones



241 $\frac{1}{2}$ –241 $\frac{3}{4}$  on the railway between Uitenhage and Graaff-Reinet (332), in the railway cutting.

*Remarks.*—The specimen described in all probability has not attained its full growth, and the manner in which the tube for about the last 2 mm. of its length has grown free from the coil suggests that we have only the commencement of an uncoiled stage illustrated in this individual. The subsequent growth of the tube was probably in a more or less nearly straight line as in *Serpula concava*, and it is impossible to say what dimensions the detached portion of the tube might attain.

In general aspect this *Serpula* very closely resembles *S. concava* (Sow.) (Upper Greensand), and agrees in the dimensions of the coiled stage, but without a sufficient number of specimens for critical comparison nothing further can be said regarding its actual affinities. A similar form from the Neocomian of France was figured by Leymerie as *Serpula lituola*.<sup>\*</sup> In the general habit and mode of growth there is also resemblance to *S. damesi* Noetling,† from the Cenomanian boulders of North Germany, but the African form differs in the smaller number of whorls, the smaller dimensions, and the thinner walls of the tube.

#### SERPULA PINCHINIANA Tate.

1867. *Serpula* (*Vermilia*) *pinchiniana* R. Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 163, pl. ix., figs. 10a–c.

The large cylindrical tubes of this form are sometimes seen attached to massive lamellibranch-shells such as *Exogyra imbricata* Krauss, or one of the pseudo-quadrates *Trigonia*. The adherent stage is irregular in the direction of its growth: it sometimes follows a sinuous course, and in some cases the tube is bent sharply back upon its path and grows over itself. The generally smooth surface of the tube is occasionally marked by irregular annular thickenings.

Mr. Rogers collected specimens from the Cliff on Buck Kraal, Sunday's River, attached to *Trigonia herzogi* (122h), and at the left side of the Coega Valley, half a mile down from the railway (458g, on *Trigonia holubi*). Another example is attached to a valve of *Exogyra imbricata* from the Sunday's River (303), belonging to the collection of the South African Museum.

<sup>\*</sup> Leymerie (3), pl. 6, fig. 5.

† Noetling (1), p. 10 [206], Taf. i., figs. 8–10.

CLASS LAMELLIBRANCHIATA.

GENUS PECTEN O. F. Müller.\*

SUB-GENUS SYNCYCLONEMA F. B. Meek.

PECTEN (SYNCYCLONEMA) ORBICULARIS J. Sowerby.

Plate II., figs. 2, 3.

1817. *Pecten orbicularis* J. Sowerby, Mineral Conchology of Great Britain, vol. ii., p. 193, tab. 186.  
1902. *Pecten (Syncyclonema) orbicularis* H. Woods, Mon. Cret. Lamell. Engl., vol. i., part iv., p. 145, pl. xxvii., and text-fig. 1. (Palæontographical Society.)

Two specimens sent to me from the South African Museum appear to differ in no respect from typical examples of this widely distributed form. One of the specimens, a single valve, has a delicate concentric banding extending over the whole surface—a character by which it may be recognised as a right valve. With the exception of its imperfect preservation in the umbonal region and its somewhat smaller dimensions, this specimen agrees very perfectly with the right valve figured by Mr. Woods in pl. xxvii., fig. 11 of his monograph (see above). The other specimen appears smooth to the naked eye, but shows minute and delicate, faint concentric markings under the lens. This represents a left valve, and it has the anterior ear preserved. Length 26·5 mm.; height 28 mm.

A small specimen (a left valve) referable to the same species was found by Mr. Rogers in the Coega River Valley. Length 13 mm.; height 15 mm.

*Locality*.—Sunday's River (279, 280). Coega Valley, on the left side of the valley, half a mile down from the railway (453g).

SUB-GENUS CAMPTONECTES F. B. Meek.

PECTEN (CAMPTONECTES) COTTALDINUS d'Orbigny.

Plate II., fig. 4.

1847. *Pecten cottaldinus* A. d'Orbigny, Paléont. Franç., Terr. Crét. vol. iii., p. 590, pl. 431, figs. 7–11.

\* For a full account of the generic and sectional divisions of *Pecten* see Verrill (1); for further references to recent literature on this subject consult Woods (3), vol. i., p. 145 (1902).



1902. *Pecten* (*Camptonectes*) *cottaldinus* H. Woods, Mon. Cret. Lamell. Engl., vol. i., part iv., p. 156, pl. xxix., figs. 1-3. (Palæontographical Society.)

A specimen collected by Messrs. Rogers and Schwarz agrees so closely with *Pecten cottaldinus* that it can only be considered identical. It is a right valve in which, unfortunately, the anterior ear is the only portion which retains the shell wholly preserved; the remainder of the valve is for the most part in the form of a cast. Here and there, where some of the inner layers of the shell are adhering to the cast, a faint and broad concentric waving is seen; this, however, does not seem to be markedly impressed upon the cast and appears to die out towards the posterior margin. It probably stands in relation to shell structure and not to surface sculpture, for the faint folds are too broad to correspond with the concentric surface markings which are exhibited by European specimens. The specimen agrees with *P. cottaldinus* in all characters of proportion and outline, as well as in the shape and relative size of the ears and the deep byssal notch.

*Dimensions*.—Length 38 mm.; height 42 mm.

*Occurrence*.—Dunbrodie, in the cliff below the old school-house on the right bank of Sunday's River (305, 306).

*Remarks*.—This form is well distributed in the Neocomian (principally the Hauterivian) and Aptian of Europe, and it has also been recorded by G. Müller from the Neocomian of German East Africa.

#### PECTEN (CAMPTONECTES) PROJECTUS Tate.

Plate II., figs. 5, 5a.

1867. *Pecten projectus* R. Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 155, pl. ix., fig. 6.

*Supplementary Descriptive Note*.—The ears are very unequal and the byssal notch deep. The delicate ornamentation of the valve surface presents a very variable aspect in different states of preservation, and under different conditions of illumination and enlargement. In frequent instances it appears to consist of fine, radiating, impressed linear striæ, diverging from the middle line and increasing by bifurcation when traced towards the valve margins. When the surface is not very perfectly preserved, these lines may appear to be separated by plain flattened interspaces, while the lines themselves may exhibit an imperfect punctate structure. Where the surface is perfectly preserved, however, the ornaments are observed to be of

a much more complex nature. If, in a suitably preserved adult specimen, the surface half-way down the valve and below this be examined under slight magnification and with favourable illumination, it is seen that the raised interspaces or minute flattened ribs themselves exhibit a peculiar punctate structure on that side of the rib nearest to the lateral margin of the valve. This is developed in such a way that the outer margin of each little rib is cut into by a series of minute wedge-shaped indentations, which leave more prominent projecting portions of the rib standing out somewhat after the manner of the hydrothecæ on a graptolitic stipe. In some cases the successive wedge-shaped grooves may almost cross the rib, but for the most part the margin of the rib which is nearest to the middle line of the valve is straight and entire.

Another peculiarity of the ornamentation is seen in some cases in the manner in which, when the radial striæ are traced upwards from the valve-margin towards the place of convergence at the middle line, by favourable illumination they may be observed to be continued upwards across the middle line, giving rise to a slight intercrossing here.

In the left valve the anterior ear is large and rectangular, the posterior ear small. This valve has a rather more equilateral aspect than the right valve, which is sometimes very markedly inequilateral.

<i>Dimensions.</i> —	(1)	(2)	(3)
Height	13	19	21 mm.
Length	12	17	20 „

No. (3) is Tate's figured type specimen.

*Occurrence.*—Railway cutting between milestones 24 $\frac{1}{2}$ –24 $\frac{3}{4}$  on the Uitenhage to Graaff-Reinet railway (297, 350); also obtained by Miss M. Wilman at Coega River. Tate says: "Collected by Dr. Rubidge in a soft, yellowish-grey, sandy limestone at the Zwartkop River Heights, and at Prince Alfred's Rest; in both localities it is frequent."

*Remarks.*—The notched sculpture of the ribs, described above, may be well observed when the preservation is exceptionally good. It appears only in faint traces in a portion of the surface of one of the specimens examined by Tate, and in other individuals less well preserved the markings only consist of radiating linear striæ, obscurely punctate in places, with smooth interspaces. A right valve from the Coega River, which agrees closely with Tate's figured type, has the surface so well preserved that the intimate details of sculpture exhibited call for the above additional descriptive note.



The delicate notched structure is also well shown in specimens from the above-mentioned locality near Uitenhage.

Tate brought this shell into relationship with *Pecten lens* Sowerby, a Jurassic form; and although it shares with this and with the Portlandian *P. morini* de Loriol\* some of the principal features which characterise these familiar Jurassic types, yet it may equally well be brought into comparison with Cretaceous forms. The Jurassic shells mentioned, besides differing in the outline, have simply striæ with a punctate structure, but no encroachment of this sculpture into the interspaces between the linear striæ. *Pecten suprajurensis* Buvignier,† an Upper Jurassic form, approaches much more closely to *P. projectus* in general character and outline, possessing a similar bulging frontal profile, but is likewise merely ornamented by delicately punctate linear striæ with smooth interspaces, attaining, moreover, much larger dimensions. *Pecten buchi* Roem.,‡ also Upper Jurassic, is well distinguished by its almost equilateral outline and by the minute transverse striations which cross the interspaces between the radial linear striæ.

*Pecten striato-punctatus* Roemer,§ from the Neocomian and Aptian of Europe, is more equilateral in outline and is more delicately ornamented; the punctate structure is much more minute and confined wholly to the striæ, leaving the very narrow intervening spaces smooth.||

*Pecten curvatus* Geinitz,¶ though having greater relative height than *P. projectus*, sometimes seems to approach the somewhat inequilateral form of this, though in figures of other shells which have been united with *P. curvatus*\*\* the valves are almost equilateral. Although Geinitz figured the magnified ornamentation of the valve-surface so as to produce an aspect of sculpture widely different from that given for instance by Reuss, yet it appears from the descriptions that punctate linear striæ with smooth interspaces characterise these forms.

Nilsson's *P. virgatus*, of Upper Chalk age from Sweden,†† is

\* de Loriol and Pellat (1), p. 107, pl. x., fig. 6.

† Buvignier (1), p. 24, pl. xix., figs. 21-23.

‡ F. A. Roemer (1), pl. xiii., fig. 8 (1836), and Nachtrag, p. 27; de Loriol, Royer and Tombeck (1), p. 389, pl. xxii., figs. 12, 13.

§ F. A. Roemer (1), Nachtrag, p. 27; d'Orbigny (3), p. 592, pl. 432, figs. 4-7 (1847); Woods (3), vol. i., p. 157, pl. xxix., figs. 4-6 (1902).

|| See also figures given by de Loriol under the name *P. arzierensis*; Loriol (3), pl. iv., figs. 3-5.

¶ Geinitz (1), p. 16, Taf. iii., fig. 13.

\*\* Geinitz (2), Theil i., p. 193, Taf. 43, fig. 15 (1872); Theil ii., Taf. 10, fig. 1, (1872); Reuss (1), part ii., p. 28, Taf. 39, fig. 6 (as *P. divaricatus*).

†† Nilsson (1), p. 22, Tab. ix., fig. 15.

more equilateral and more coarsely ornamented than *P. projectus*, and it has been shown, moreover, by Hennig\* that Nilsson's unsatisfactory figure is misleading; this shell really has relatively strong ribs with linear interspaces, increasing by division and insertion and not diverging from the middle line in the manner represented by Nilsson. The delicate transverse striæ which cross the radial ornaments are scarcely comparable with the notching of the "ribs" shown by *P. projectus*. The shell from the Gosau beds described by Zittel under the name *P. virgatus*† is almost equilateral, and is much higher in outline than *P. projectus*.

The shell from the Cretaceous of the east end of Maud Island (Queen Charlotte Islands), ascribed to *Camptonectes curvatus* Geinitz by Whiteaves,‡ is somewhat similar to *P. projectus*, to judge from the figure of a right valve, but it is more equilateral in form.

A *Pecten* from the Neocomian in German East Africa was described by G. Müller§ under the name *P. striato-punctatus*, but the specimen figured is so preserved that a comparison with *P. projectus* is difficult, although it appears to differ from this in being more equilateral.

*Pecten* (*Camptonectes*) *pueyrriodonensis* Stanton,|| from the Belgrano beds (Lower Cretaceous) of Patagonia is another shell of similar type, but differs at least in the more equilateral form of the right valve.

*Pecten kamerunensis* von Koenen,¶ from Lower Cretaceous strata in the Cameroons, differs from *P. projectus* by the more equilateral form and the rather coarser ornamentation, with stronger lateral rib-development. Von Koenen describes how the furrows appear here and there divided by swellings into little grooves, but says that this stands in connection with the crossing of lines of growth—a relation not to be observed in the minute ornamentation of *P. projectus*.

#### SUB-GENUS CHLAMYS J. F. Bolten.

PECTEN (CHLAMYS) cf. SUBACUTUS Lamarck.

Plate II., figs. 6, 6a.

Cf. 1819. *Pecten subacutus* J. B. de Lamarck, Hist. Nat. des Anim. sans Vert., vol. vi., p. 181.

\* Hennig (1), p. 41, pl. 2, figs. 28, 33.

† Zittel (2), p. 109, pl. xvii., fig. 8.

‡ Whiteaves (3), p. 242, pl. 32, fig. 4.

§ G. Müller (1), p. 550, Taf. 24, fig. 7.

|| Stanton (3), p. 12, pl. iv., fig. 1.

¶ von Koenen (1), p. 20, Taf. iii., figs. 14, 15.



- Cf. 1847. *Pecten subacutus* A. d'Orbigny, Paléont. Franç., Terr. Crét., vol. iii., p. 605, pl. 435, figs. 5-10.  
,, 1872. *Pecten subacutus* H. B. Geinitz, Das Elbthalgeb. in Sachsen, part i., p. 195, pl. xlv., fig. 5 (Palæontographica, vol. xx.).  
,, 1902. *Pecten (Chlamys) subacutus* H. Woods, Mon. Cret. Lamell. Engl., vol. i., part iv., p. 169, pl. xxxi., figs. 7-9. (Palæontographical Society.)

*Descriptive Note.*—A single specimen sent from the collection of the South African Museum seems to approach very closely to *P. subacutus*. The shell is ovate in outline, prolonged dorsally, with an acute apical angle (about 80°). The inflation is slight, with the left valve a little more convex than the right.

The valves are ornamented by about 22 strong, angular ribs with sharp summits. Near the inferior margin the summits of the ribs are separated from one another by a distance of about 2 mm. On parts of the shell the ribs are studded with numerous blunt, spinose projections. Where the surface is well preserved the ribs and interspaces are seen to be ornamented by very delicate, transverse linear markings, most clearly visible in the interspaces. Near the inferior margin these become obscurely developed and are masked by coarser ridges and grooves of accretion. The hinge-line and ears are unfortunately not preserved, but having regard to the other characters there is no reason to suppose that they differed essentially from those of *P. subacutus*.

*Dimensions.*—Height (about) 42 mm.; length 35 mm.

*Occurrence.*—Marine Beds of Sunday's River (304).

*Remarks.*—*Pecten subacutus* is characteristic of the Cenomanian in Europe, but this African shell approaches more closely to it than to any form from the Lower Cretaceous with which I am acquainted. In the imperfect material at disposal, no features are apparent which would justify a definite separation from the European form, yet in the absence of the ears in this specimen and the lack of further comparative material, the question of identity must remain open.

*Pecten urgonensis* de Loriol,\* common in the Urganian of Grand Salève, is a shell of very similar type, so far as can be judged from de Loriol's description and figures; but apparently its scaly ornaments are larger and more prominent, and the surface is perhaps more coarsely ribbed.

\* de Loriol (2), p. 389, pl. C, figs. 25, 26.

GENUS LIMA J. G. Bruguière.

SUB-GENUS ACESTA H. and A. Adams.

LIMA (ACESTA) OBLIQUISSIMA Tate.

Plate II., fig. 7.

1867. *Lima obliquissima* R. Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 156, pl. ix., fig. 5.

*Supplementary Descriptive Note.*—The shell has great height in comparison with length. The posterior outline is gently rounded, the anterior profile straight. The straight anterior border passes at its lower end by a somewhat sudden curve into the rounded inferior border. The valves are most convex in the umbonal half and near the anterior side; they become flatter posteriorly and inferiorly. Anteriorly, the flank passes abruptly, though without marked carination, into an extensive, flat frontal face, truncating the shell. This frontal area is in no degree sunk or concave in form. The umbones are acute and sharp, terminal at the anterior extremity of the hinge-line; the superior border of the shell is straight and very short, and truncates the shell to form a right angle with the anterior border. The anterior ear is rudimentary or not developed; the posterior ear is much reduced, and not definitely demarcated from the flank.

The ornamentation consists of delicate linear radial grooves, very crowded near the umbo, gradually diverging until, at a distance of 40 mm. from the umbo, they may be separated by interspaces 2 mm. broad. At a distance exceeding 30 mm. from the umbo, these lines are almost or quite absent from the middle part of the flank, though well impressed on the lateral parts. The lines follow a more or less irregular and wavy course and are sometimes suddenly deflected to right or left when traced down from a prominent concentric growth-line. When well preserved, the linear ornaments show a minutely punctate structure, most perfectly developed in the umbonal half of an adult shell. The interspaces are very gently convex or are flat, but are without sculpture. On the frontal area the ornaments are of a more pronounced character, and may take the form of imbricating ridges with the edges directed away from the valve-margin. They radiate from the umbonal region and pass along the frontal face, gradually approaching the frontal valve-margin and forming an acute angle with this. On the frontal area, therefore, the ornaments are very obliquely crossed by the lines of accretion.



*Dimensions.*—

Greatest measurement radially from the umbo ... 64 mm.

Greatest length measurement, at right angles to  
the last ..... 40 „

Greatest depth of a single valve ..... 10 „

*Occurrence.*—Railway cutting between milestones 24 $\frac{1}{2}$ –24 $\frac{3}{4}$  on the line from Uitenhage to Graaff-Reinet, about three miles from Uitenhage (346); also stated to occur at Grass Ridge. Specimens in the collection of the Geological Society are labelled “Sunday River” (Rubidge) and “Zwartkop River” (H. Longlands). Tate’s record of locality is “in a yellow shell-rock from the Zwartkop River sandstone, with *Placunopsis undulata* and fossil wood (Rubidge).” Fine specimens sent to me from the South African Museum are from the Sunday’s River. Mr. Rogers obtained this form on the left side of the Coega Valley, half a mile down from the railway (455g).

*Remarks.*—Tate unhappily brought this shell into comparison with two British Jurassic forms, *L. rigidula* (Phill.) from the Cornbrash, and *L. ovalis* (J. Sow.) from the Great Oolite. *Lima rigidula*\* is of quite another type; it has a widely different outline, is comparatively coarsely ornamented, and has well-developed anterior and posterior ears. *L. ovalis*,† more oblique and anteriorly produced, with minutely delicate and crowded linear ornaments, can scarcely be brought into close comparison.

*Lima obliquissima* in reality may be most closely compared with those shells to which has been applied the sub-generic name *Acesta*,‡ represented in Cretaceous and later strata, and existing at the present day. The characters whereby this group of forms is distinguished from *Plagiostoma* and other divisions of the genus have been clearly set forth by E. Philippi in his analysis of *Lima*.§ Although I have as yet been unable to ascertain the position and form of the ligament pit in *L. obliquissima*, the close agreement in other features can leave little or no doubt that this shell must be united with *Acesta*, if this sub-generic group be adopted at all. These features are principally seen in the great relative height of the valve; the anteriorly little-produced outline; the anterior and terminal position of the umbones; the great reduction of the anterior ear and the imperfectly demarcated posterior ear. The fine linear

\* Phillips (1), p. 116, pl. vii., fig. 13.

† J. Sowerby (1), tab. 114, fig. 3 (1815); Morris and Lycett (1), Part 2, p. 29, pl. iii., fig. 5.

‡ H. and A. Adams (1), p. 558.

§ E. Philippi (1), p. 630.

sculpture of the flank, it is true, recalls that of some *Plagiostoma*, but the shell is in other respects strongly contrasted with that group. Concerning the value of the sub-generic name *Acesta*, particularly in the application to fossil forms, opinions have widely differed. It was accepted by Stoliczka\* and by Zittel,† and latterly by Philippi, while regarded by Fischer as only representing a section of *Lima*.‡ This last author merely quotes the living type species, *L. excavata*. G. Boehm, however, has expressed the opinion that the sub-genus *Acesta* cannot be upheld,§ pointing out that the original diagnosis is inaccurate; that the name is unpractical in its application to fossil forms, in many of which the direction and position of the ligament pit, upon which the exact determination depends, cannot be investigated; and further, that the distinctive features of the proposed sub-genus are of slight importance. The first of these objections can have little weight, merely depending, as pointed out by Philippi, upon an original error of orientation. There is something to be said for the last point, perhaps, and it is clear that amongst fossil representatives of the genus there are some forms which illustrate in varying degrees the inequilateral character and the development of the anterior auricle. The name, however, though possibly not standing for a natural group, may for the present be conveniently employed to indicate the apparent affinities of the forms to which it is applied.

*L. obliquissima* shows a striking outward similarity to the typical living *Lima* (*Acesta*) *excavata* (Fabr.) Chemn.,|| though differing from this by the relatively more elongated outline, the shorter hinge-line, and the more restricted posterior cardinal expansion of the flank. A Neocomian shell having great resemblance in form to *L. obliquissima* is *Lima undata* (Desh.) Leym.,¶ but it is distinguished by its longer hinge-line and stronger ornaments. In the shortness of the superior margin and the character of the surface ornamentation, *Lima orbignyana* Math.\*\* shows closer agreement, but it is distinguished from *L. obliquissima* by the more perfectly demarcated posterior ear, the concave outline behind this, the concave anterior area and the extension of linear ornaments over the whole flank. Matheron's figure shows a distinctly developed projecting anterior

\* Stoliczka (2), pp. 413-415.

† Zittel (5), p. 26 (1881).

‡ Fischer (1), p. 941 (1886).

§ G. Boehm (1), p. 625.

|| E. Philippi (1), Taf. xxiv., fig. 5.

¶ Leymerie (2), p. 10, pl. 8, fig. 8; d'Orbigny (3), p. 528, pl. 414, figs. 9-12 (1847).

\*\* Matheron (1), p. 182, pl. 29, figs. 3, 4



auricle, though this is represented as much more reduced in the figure given by d'Orbigny.

A *Lima* from the Lower Cretaceous of England, ascribed by W. Keeping\* to Roemer's *L. longa*, shows great similarity in general form and outline. It differs, however, from the African shell by the relatively longer hinge-line and more extensive posterior ear, and although appearing to vary considerably in regard to the surface ornamentation, is characterised by a more pronounced type of radial sculpture; *L. longa* is further distinguished by the possession of great height measurement in proportion to its length.†

There is closer agreement, again, between *L. obliquissima* and *L. tenuitesta* Whitfield,‡ from Upper Cretaceous rocks in Syria. The two are practically identical in outline and the relative length of the superior border, but *L. tenuitesta* has the linear striæ of the surface more numerous and closely crowded at a given distance from the umbonal apex.

#### SUB-GENUS MANTELLUM J. F. Bolten.

##### LIMA (MANTELLUM) NEGLECTA Tate.

Plate II., figs. 8, 8a.

1867. *Lima neglecta* R. Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 156, pl. vii., figs. 4a, 4b.

Three specimens, all left valves, are referable to this species. The ribs are acutely ridged, with sharp summits. The middle of the angular interspace is sometimes occupied by a fine linear ridge, and occasionally a second one may be present. These are stronger than the numerous, delicate, linear ridges which are developed on the sloping sides of the main ribs.

A specimen 20 mm. in length has a greatest diameter, measured at right angles to the length, of about 12 mm.

*Occurrence*.—On the left side of the Coega Valley, half a mile down from the railway (448g, 449g, 453g). The specimen described by Tate, numbered 11,013 in the collection of the Geological Society of London, came from the Sunday's River.

*Remarks*.—Tate's figure of this species is very inadequate, and does not give a good idea of the shell. The appearance of two sets

\* Keeping (1), p. 112, pl. v., fig. 6.

† F. A. Roemer (1), p. 79, Taf. xiii., fig. 11 (1836); (2), p. 57 (1841). Since the above lines were written, Mr. H. Woods has published an account of this shell and considers that the Upware specimens were rightly identified with the German form: Woods (3), vol. ii., p. 25 (1904).

‡ Whitfield (1), p. 390, pl. iv.A, figs. 1, 2.

of ribs directed away from a dividing line, so clear a feature in the figure, is quite erroneous. In the specimen itself, an appearance of dichotomy occurs only in one rib, and this seems to be due to an accident of preservation. There is a crack in the shell, and a portion of the valve on one side has become pushed slightly over the surface on the other side of the crack. From an examination of the specimen it is difficult to say with certainty whether this injury took place during the life of the animal, or subsequently, but the resulting irregularity in the sculpture was in any case not a normal character.

There is a close general resemblance between *L. (Mantellum) neglecta* and *L. parallela* J. de C. Sow.;\* but in *Lima neglecta* the oblique elongation is greater and the posterior ribs are more crowded and delicate. *Lima (Mantellum) gaultina* Woods† is more closely similar to *L. neglecta* in outline, but its antero-ventral border is more narrowed, and the fine linear rib in the interspace between the main ribs is lacking.

#### GENUS PERNA J. G. Bruguière.

##### PERNA ATHERSTONI Sharpe.

##### Plate II., fig. 9.

1856. *Perna atherstoni* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 193, pl. xxii., figs. 4, 4a.

*Occurrence.*—This shell was found at Dunbrodie (Sunday's River), in the cliff below the old school-house (282, 305, 320), and at Walton's Farm, below Dunbrodie (311). It was recorded by Sharpe from the same place (Geelhoutboom) "in greenish grit with fragmentary shells."

*Remarks.*—These specimens from Dunbrodie were thought to represent very probably a new form, but a comparison with Sharpe's original specimens of *P. atherstoni* shows that they differ from these in no essential particular. One of the Dunbrodie individuals, it is true, shows a slight difference in outline; its antero-inferior border, at a distance of 15 mm. from the umbonal apex, has a broad indentation or inward curve in profile, somewhat more strongly developed than in the original of Sharpe's figure 4. Other specimens which I have examined exhibit this feature in less degree, and it appears to be a character which is subject to some individual

\* For full description and references to literature see Woods (3), vol. ii., part 1, p. 28, pl. v., figs. 14, 15 (1904).

† Woods (3), vol. ii., part 1, p. 31, pl. v., figs. 16–20 (1904).



variation. The convex fold of the valve, passing back from the umbo, is marked off from a small, flattened, marginal portion of the valve between the fold and the antero-inferior margin near the umbonal end, in clearer manner as a rule than is depicted in Sharpe's figure. In this respect the figure is misleading, for the fold is well developed in the original specimen. In another point, also, the illustration leaves something to be desired; the postero-inferior border, restored by a dotted line, should in reality have been represented as a rounded curve similar to that followed by the outline of the same part in *Perna mytiloides* Lam., and should not have been drawn in the angular or sub-angular form which lends such a false aspect to the outline of the shell as depicted in Sharpe's work.

*P. atherstoni* is characterised by its oblique figure and the relatively great length of the hinge-line. In these features it recalls *P. mytiloides* Lam., from the Upper Oolites of England,\* which in general aspect it much resembles; but in *P. atherstoni* the shell is less sharply pointed and produced at the umbo, is less inflated anteriorly, and is more obliquely elongated. There are further points of difference which it is unnecessary to recount.

#### GENUS PINNA Linnæus.

##### PINNA ATHERSTONI Sharpe.

1856. *Pinna atherstoni* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 193, pl. xxii., fig. 1.

*Occurrence*.—Railway cutting between milestones  $24\frac{1}{2}$ – $24\frac{3}{4}$  on the railway from Uitenhage to Graaff-Reinet, about three miles from Uitenhage (329, 330), where it is very abundant in a bed of nodular limestone.

*Remarks*.—It has been noted by Messrs. Rogers and Schwarz that this shell, associated with *Holcostephanus atherstoni*, marks the most constantly recognisable zone in the Marine Beds of the Zwartkop's River valley.

*Pinna atherstoni* was compared by Sharpe and Tate with *P. hartmanni* Zieten, from the Lias of Europe, and it certainly agrees more closely with *P. hartmanni*, as figured by Goldfuss,† than with the generality of Cretaceous forms, most of which are more elongated and slender in outline. The original figure given by Zieten ‡

\* Damon (1), pl. ii., fig. 5.

† Goldfuss (1), Band ii., p. 164, Tab. cxxvii., fig. 3b (1837).

‡ Zieten (1), p. 73, Tab. 55, fig. 5 (1833).

has, however, a very different aspect from that of Goldfuss; it apparently has a narrower apical angle, and the surface ornaments are so delineated as to be scarcely comparable with those of *P. atherstoni*. The resemblance of *P. atherstoni* to the Liassic form usually known by Zieten's name is clearly a fact of no importance in the question of the age of the Uitenhage fauna. It may be noted that a specimen of *Pinna* from the *Perna*-bed of Atherfield, Isle of Wight, preserved in the Sedgwick Museum at Cambridge, has form and proportions closely similar to those of *P. atherstoni*. The specimen is unfortunately ill-preserved and unfitted for a detailed comparison. A similarly broad form has also been recorded from the Buda Limestone, the upper part of the Lower Cretaceous series of Texas.\*

## GENUS OSTREA Linnaeus.

## OSTREA sp.

Specimens of *Ostrea* (305, 306, 336) which occur in the cliff below the old school-house at Dunbrodie (right bank of Sunday's River), in association with *Perna atherstoni*, *Pecten cottaldinus* and *Gastrochæna dominicalis*, are in a very poor state of preservation and consist chiefly of fragments. Valves of flattened form measure upwards of 40 mm. from the umbo to the opposite border and about 30 mm. from margin to margin in a direction perpendicular to this. The outline of the valve becomes broadly pointed at the umbonal end. Other imperfect individuals are represented by valves of smaller dimensions, and these appear to be less elongated and more convex. None of the valves suffices for specific determination, but it is probable that two forms are represented.

## GENUS EXOXYRA T. Say.

## EXOXYRA IMBRICATA Krauss.

1843. *Exogyra imbricata* F. Krauss, Amtlicher Bericht über die zwanzigste Versammlung der Gesellsch. deutsch. Naturforscher und Aerzte zu Mainz im Sept., 1842, p. 129.
1850. *Exogyra imbricata* F. Krauss, Nov. Act. Acad. Cæs. Leop.-Carol. Nat. Cur., vol. xxii., pt. 2, p. 460, Tab. 50, figs. 2a-2d.
1856. *Gryphæa imbricata* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 197, pl. xxiii., figs. 3a, 3b.

\* Shattuck (1), p. 19, pl. vii.



1867. *Ostrea imbricata* R. Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 154.

1904. *Pycnodonta imbricata* H. Douvillé, Bull. Soc. Géol. France, ser. 4, tome iv., p. 215.

*Occurrence*.—This form is widely and abundantly distributed in the Marine Beds of the Zwartkop's, Sunday's, and Coega River valleys. It was met with at almost all the exposures in the Zwartkop's valley visited by Messrs. Rogers and Schwarz. Examples sent to me are from the railway cutting between milestones  $24\frac{1}{2}$ – $24\frac{3}{4}$  on the railway from Uitenhage to Graaff-Reinet (312), and others were collected by Miss M. Wilman at Coega. Specimens sent from the collection of the South African Museum are from the Sunday's River (300, 301, 302, 303).

*Remarks*.—A striking character of the late adult and senile condition of *E. imbricata* consists in the prodigal manner in which shell substance is added at the margins of the valves, particularly noticeable in the smaller (right) valve in the neighbourhood of the hinge. Here, with its margin consisting of many coarse, imbricating laminæ, this valve may attain a thickness exceeding 30 mm. The ligament pit is seen to be strongly curved near the apex, but straight in the portion representing the later growth-stages.

This abundant and characteristic shell has given rise to some differences of opinion concerning its generic position within the Ostreidæ, which, however, may be sufficiently accounted for by the great variability of form exhibited by different individuals, and by the fact that the shell presents features which are recognised as leading characteristics of both *Exogyra* and *Gryphæa*. For this reason Tate used the name *Ostrea* in the broad sense, stating his opinion that the species in question "affords a good illustration of the mere sectional value (which cannot at all times be employed) of the groups *Exogyra* and *Gryphæa*." In many instances, it must be admitted, apparent passage forms seem to render difficult the definite separation of the three genera, so easily distinguishable when represented in their more characteristic aspects.\* Jackson has made some luminous observations on the relation of these three genera and on the influence of the character of attachment by cementation in producing modifications in members of the Ostreidæ.† He believes that *Gryphæa* and *Exogyra* "are probably aberrant members of the Ostreidæ, not typical forms in the line of evolution of the group."

\* Leymerie (1a). See also Peron's remarks on these genera, Peron (1), pp. 107–9.

† Jackson (1), sections v. and vii.

It is highly probable that the shells classed as *Gryphæa* do not represent a homogenetic group, but are polyphyletic in origin, including repeated offshoots from an ostrean stock. While, in the progress from *Ostrea* to *Gryphæa*, there is diminished duration of the attached habit, so that the typical *Gryphæa* is fixed by cementation of the left valve only during the young stage, examples are not wanting in which the highly specialised characters of *Gryphæa* are seen to become modified by the acquirement once again of more prolonged attachment. As an instance of this, reference may be made to the shells which, at the close of the deposition of the Oxford clay in England, seem to have largely replaced the familiar *Gryphæa dilatata* J. Sow. In these modified forms, the attached valve did not become free until the neanic stage had been completed or the adult stage had been well entered upon, and the shell therefore perforce retained a relatively flatter and more ostreiform aspect.\* *Exogyra imbricata* might be thought, on cursory examination, to bear no slight analogy to these: the area of attachment has very frequently a similar relation, in point of dimensions, to the whole fully-grown valve, and it is only on the cessation of attachment that the individual acquires the manner of growth of a *Gryphæa* and develops the arcuate form which led Sharpe to institute comparison with Liassic shells. It must be realised, however, that in this African form we have an illustration of the passage from a more complete to a less persistent duration of attachment, in the life of the individual, for a study of the youthful stage shows beyond doubt the exogyrate ancestry, and this may be clearly seen in many specimens in which the nature of the youthful characters did not become masked by the modifications incidental to fixation. The duration of attachment varied very much in different individuals, and no doubt often depended upon the nature and form of the object to which the young shell adhered. In some cases a relatively large area of attachment may retain the impress of some foreign surface, such as that of the large and coarsely ribbed *Cucullæa kraussi* Tate, or a pseudo-quadrate *Trigonia*, in a manner which largely obscures the true nature of the umbonal region. Other individuals, again, seem to have secured themselves to some less suitable or stable surface, and at an earlier stage to have entered upon the period of freedom. In these, as in some which have been attached to an even surface, the characters of the fixed stages are clearly seen to be those of a true *Exogyra*, and present the strongest contrast to

\* Compare also figure of *Gryphæa alligata* from the Corallian of Nattheim Quenstedt (1), p. 752, Tab. 91, fig. 25 (1857).



the features of the nepionic and neanic stages of *Gryphæa* as illustrated, for instance, in the admirable descriptions and figures given by Hill and Vaughan of members of the genus occurring in the Lower Cretaceous strata of Texas.\* When we see how closely the manner of growth in the adult stage of *E. imbricata* often simulates that of a true *Gryphæa* with simple ostrean ancestry, it must be admitted that the parallelism is very striking.

It would be difficult to indicate within narrow limits the true relationship of *Exogyra imbricata*, but it is evident that its nearest morphic counterparts are essentially characteristic of Lower Cretaceous rocks. Thus, a very close resemblance exists between this form and some of the shells classed by Leymerie under the name *Exogyra sinuata* and *E. subsinuata*. Leymerie first regarded all these as varieties of *Exogyra sinuata*,† and included forms to which numerous specific names had previously been applied. He subsequently separated *E. subsinuata* as a species distinct from *E. sinuata*, and used several varietal designations of both. Regarding the value of the nomenclature employed by this author or by Coquand‡ in dealing with the forms comprised within this perplexing group, I am at present unable to attempt the critical and detailed study which alone would warrant the expression of any judgment; in like manner, the varying use of the name *Exogyra couloni* by different authors has given rise to such a degree of confusion that, in instituting comparisons, it must suffice to make reference to actual figures or descriptions, leaving aside for the time being all question of the value or correctness of the specific names attached to certain of these.

Krauss rightly recognised the broad relationships of *E. imbricata* and believed it to be nearly related to "*Gryphæa couloni* DeFr.," from which, however, he found it to differ in the following points: "It is larger, more thick-shelled, longer and narrower; has a keel narrower at the end (though always rounded), more concave laminæ lying much higher one upon the other, and a stronger umbo bent further over the opercular valve, than in *Gryphæa couloni* DeFr." Some of the shells figured by d'Orbigny as *Ostrea couloni*§ show no slight resemblance to selected individuals of *E. imbricata*, but are narrower than the generality of the Uitenhage specimens, and the imbricating lamellæ of the larger valve are more prominent and irregular. The broad, plicated specimens figured by d'Orbigny under the same name on plate 466 of his work cannot be brought

\* Hill and Vaughan (1).

† Leymerie (1).

‡ Coquand (2).

§ d'Orbigny (3), pl. 467, figs. 1-3 (1848).

into comparison. The shells figured by Coquand\* as *Ostrea couloni* include narrow forms, more elongated and more decidedly carinated than *E. imbricata*, as well as a broad type, developing plications of the larger valve in the later adult stage, which is in no respect closely comparable with the form we are considering.

Sowerby's *Exogyra sinuata*,† though itself very variable, is typically widely separated from *E. imbricata* by the strong carination of the larger valve and the widely expanding form of this, with the much less arcuate habit of growth and the considerably greater adult dimensions. Some French forms figured by Leymerie and brought into relationship with Sowerby's species, though perhaps erroneously, afford, on the other hand, material for a close comparison with *E. imbricata*. Thus, Leymerie's *E. sinuata*, var. *elongata*‡ can be fairly closely matched, while extreme individuals of *E. imbricata*, in their narrow outline and very arcuate growth, nearly resemble that author's figure of *E. subsinuata*, var. *aquilina*.§ The shell from the Neocomian of the Haute-Marne figured by Bayle|| as *Aetostreon aquilinum* (Leym.), again, closely resembles very narrow and curved specimens of the African form.

*Ostrea tardensis* Stanton,¶ from the Lower Cretaceous Gio beds of Patagonia, may, in selected individuals, somewhat closely approach *E. imbricata*, but its near relationship to this must be considered doubtful; it seems, however, to represent in some respects an analogous type. The exogyrate character of the umbonal region is only feebly indicated, according to Dr. Stanton, who says that the "lower valve is very thick and very convex, obscurely carinate, with the beak more or less twisted laterally, but not distinctly coiled." It differs also by frequently acquiring a marked crescentic form in the adult. If the Patagonian shell had a true exogyrate ancestry, which appears probable, the early characters seem to have so far disappeared as to indicate that relationship to *E. imbricata* is probably somewhat remote.

The shell from the Neocomian of Arqueros in Chili described by Bayle and Coquand as *Ostrea couloni*,\*\* and afterwards brought into association with a heterogeneous company under the collective name

\* Coquand (2), p. 180, pl. 65, fig. 10; pl. 71, figs. 8-10; pl. 74, figs. 1-5; pl. 75, figs. 1-6, 22.

† J. Sowerby (1), vol. iv., Tab. 336 (1822). [As *Gryphæa*.]

‡ Leymerie (2), p. 17, pl. 12, fig. 2.

§ Ibid., pl. 12, figs. 6, 7.

|| Bayle (1), pl. cxl., figs. 3-5.

¶ Stanton (3), p. 11, pl. i., figs. 1, 2; pl. ii., figs. 1, 2.

\*\* Bayle and Coquand (1), p. 37, pl. vii., figs. 1, 2.



"*Ostrea aquilina*" by Coquand,\* closely resembles many specimens of *E. imbricata* in the form and inflation of the valves and in the degree of curvature of the umbonal region; but it differs by the more marked carination of the larger valve. Remes has considered both the Chilian shell and *Exogyra imbricata* Krauss to be identical with Sowerby's *Exogyra sinuata*,† but this is certainly an error. The same author, however, has figured an *Exogyra* from Stramberg,‡ ascribed by him to *Exogyra subsinuata* Leym., to which selected individuals of *E. imbricata*, in which the surface of attachment is relatively large, may show considerable resemblance.

An exogyrate shell from the Bajocian of Abyssinia was ascribed by Douvillé§ to *E. imbricata* Krauss, but this was an erroneous identification, as already pointed out by G. Müller.|| The resemblance of the small specimens figured by Douvillé to selected young individuals of *E. imbricata* is indeed not a distant one, but many of the Uitenhage specimens are attached by a very much larger surface, and, moreover, attain a colossal size in comparison with Douvillé's types, if these represent the adult stage. The variation in *E. imbricata* is so great that a more detailed and critical comparison could not be entered upon without a substantial suite of specimens of the Abyssinian shell.

A shell from the Isakondry basin in Madagascar (presumably from strata of Lower Cretaceous age) is stated by Douvillé to bear a close resemblance to *Exogyra imbricata* Krauss.¶

## GENUS MYTILUS Linnæus.

### MYTILUS UITENHAGENSIS sp. nov.

Plate II., figs. 10, 11, 11a.

*Description.*—The shell is slender and elongated in outline, sharply pointed in front, and antero-ventrally truncated. The hinge-margin is straight, and passes backwardly by a curve into the obliquely sloping posterior margin, which is only very slightly convex in outline until the posterior end of the valve is reached. In profile, the antero-ventral margin is straight, passing from the acutely pointed umbo to the posterior angle of the valve, where it abruptly cuts the curved outline of the posterior margin.

The antero-ventral area is flat, and its surface is perpendicular

\* Coquand (2), p. 158.

† Remes (1), p. 216.

‡ Remes (1), pl. xxi. (iv.), figs. 2a, 2b.

§ Douvillé (1), p. 230, pl. xii., figs. 8, 9.

|| G. Müller (1), pp. 569, 570.

¶ Douvillé (2), p. 388; Douvillé (4), p. 215; Lemoine (1), p. 176.

to the plane of symmetry of the valves. The junction of this portion of each valve with the very gently convex upper portion is acutely angular, giving rise to a sharp carinal ridge which, however, becomes very slightly blunted towards the posterior end of the valve.

The shell is devoid of sculpture, but its smooth upper surface is marked by numerous delicate growth-lines which form a sweeping curve between the hinge-margin and the carinal ridge. The antero-ventral area is sometimes marked by coarser, rounded, obliquely running ridges of accretion. Traces of the narrow, elongated, fossilised ligament have been observed.

*Dimensions.*—

Length of the antero-ventral margin .....	37 mm.
Length of the cardinal margin.....	16 „
Greatest breadth of flank between the carinal ridge and the posterior valve-margin.....	13 „
Greatest width of the antero-ventral area in one valve .....	7 „

*Occurrence.*—Found at Dunbrodie, Sunday's River (319). Specimens collected by Atherstone and preserved in the British Museum (Natural History) are labelled "Cuylers." Also collected by Mr. Rogers from the lowest beds on Zoet Geneugd, right bank of Sunday's River (64h), and in the Coega Valley, one mile up the line from Coega station (479g).

*Remarks.*—This is doubtless the form noticed by Krauss\* in the lowest fossil-bearing beds on the left bank of the Zwartkop's River below Uitenhage, in association with *Trigonia herzogi*, *T. conocardiformis*, and *T. ventricosa*. Krauss speaks of a *Mytilus* "with a sharp ridge running from the umbo to the hinder extremity and a flat truncated surface extending from this ridge to the ventral margin." The shell was capable of attaining dimensions exceeding those of the larger specimen figured here. A specimen in the Geological Society's collection, incomplete at the posterior end, must have originally measured 50 mm. in length; the maximum breadth of its flat area is 11 mm. in each valve. Two imperfect large valves now preserved in the British Museum (Nat. Hist.), which form part of a collection at one time placed in the Museum of Practical Geology, probably had a length of fully 45 mm. when complete. The antero-ventral area measures about 9 mm. in breadth in one of these, while the greatest breadth of the flank, measured by a line perpendicular to the carinal margin, is 18 mm. The area is perfectly flat and the carinal ridge acutely sharp.

In the absence of knowledge regarding the interior of the shell,

\* Krauss (2), p. 443.



this form can at present only be looked upon as a representative of the genus *Mytilus*. No doubt, indeed, concerning its generic position could have been reasonably suggested, had not a detailed study of the externally very similar *Mytilus lanceolatus* J. de C. Sowerby, led Mr. H. Woods to ascribe that shell to the genus *Dreissensia*,\* a determination which was based upon the presence of an umbonal septum. A strong case was made out by Mr. Woods for the existence of marine forerunners of the modern *Dreissensia*, an inhabitant of brackish and fresh waters, and he was also supported by the opinion of M. Cossmann, who has found the genus to be associated with marine forms in the Upper Eocene of the Paris basin. In view of close external similarity to *Dreissensia lanceolata* it would not be surprising if the shell here described were eventually also shown to be furnished with an umbonal plate, but until this can be proved it will be necessary to retain the name *Mytilus*.

Compared with *Dreissensia lanceolata* (= *Mytilus lanceolatus* J. de C. Sow.)† from the Lower Greensand and Upper Greensand and Blackdown Beds of England, *M. witenhagensis* is seen to agree closely in general form, but to be distinguished by several points of detail. In the African shell the antero-ventral area is flat throughout its extent, which is not the case in the European form; in *M. witenhagensis* the carinal ridge is more sharply acute in the umbonal region than in many examples of *D. lanceolata*. Further distinguishing features possessed by *M. witenhagensis* are the relatively slightly shorter hinge-line, the less steeply sloping outline of the posterior margin, the relative narrowness of the flank between the carinal ridge and the posterior margin, and the absence of concentric ornaments at any stage of growth. The shell from the Cretaceous of Shingle Bay, Skidegate Inlet (Queen Charlotte Islands), described by Whiteaves under the name *Mytilus lanceolatus*,‡ may or may not be identical with the European form. To judge from the description and figures, it shows considerable similarity to *M. witenhagensis*, though appearing to differ by the imperceptible passage of the hinge-border into the posterior border, the curved outline of the carinal margin, and the concavity of the antero-ventral area.

Several forms described from the Senonian Greensand of Aachen

\* Woods (3), vol. i., p. 110 (1900).

† J. de C. Sowerby (1), vol. v., p. 55, Tab. 439, fig. 2 (1823); H. Woods (3), vol. i., p. 110, pl. xviii., figs. 13-15, pl. xix., figs. 1-11 (1900).

‡ Whiteaves (3), p. 236, pl. 31, figs. 7, 7a.

by J. Müller,\* and united by Holzapfel† under the name *Septifer tegulatus*, may possibly be identical with Sowerby's *M. lanceolatus*, according to the view of Prof. Holzapfel and Mr. H. Woods. While the points of difference from *M. uitenhagensis* are in the main those noted above in the case of the English shell, the specimens from Aachen dealt with by Prof. Holzapfel appear to be still more strongly distinguished by their frequently curved antero-ventral margin and their well-marked concentric ornament.

In *Mytilus tornacensis* d'Archiac,‡ from the Tourtia of Tournay, the hinge-line is relatively longer than in *M. uitenhagensis*, while the antero-ventral area is not flat and the carina is much less sharp; there are also markings on the shell at right angles to the lines of growth.

A form bearing greater similarity to *M. uitenhagensis* is *Mytilus triangularis* J. Böhm,§ from the Trigonian-sandstone of Lebanon.|| This has a similar elongated outline, sharp carinal ridge and flattened antero-ventral area; but it is apparently well distinguished by the manner in which the hinge-margin and posterior margin pass imperceptibly by a curve into one another when viewed in profile. In *M. triangularis*, too, the flank between the carina and the posterior margin is slightly narrower, while Dr. Böhm's figure 11b represents the outline of the carina as somewhat curved.

In order to illustrate how great a sameness of characters may persist or recur in mytiloid shells, it is only necessary to refer to such a form as *M. aviothensis* Buv.¶ from the Lias of Avioth, Breux. This closely resembles *M. triangularis*, from the Syrian Cretaceous, in most outward characters, and differs from *M. uitenhagensis* chiefly in those points which distinguish *M. triangularis* also, though exhibiting a slight convexity of the antero-ventral area not developed in these Cretaceous forms.

## GENUS MODIOLA Lamarck.

### MODIOLA BAINI Sharpe.

#### Plate II., figs. 12, 12a.

1856. *Modiola bainii* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 193, pl. xxii., figs. 2, 3.

*Supplementary Descriptive Note.*—As an addition to Sharpe's description, it may be noted that the oblique lateral "keel" is only

\* J. Müller (1), p. 35.

† Holzapfel (1), p. 218, Taf. xxv., figs. 1-9.

‡ d'Archiac (1), p. 307, pl. xv., fig. 3. § J. Böhm (2), p. 218, Taf. vii., fig. 11.

|| For remarks on the age of this sandstone see Rehbindler (1), p. 87.

¶ Buvignier (1), p. 24, pl. xvi., figs. 35-37.



developed as a rounded folding of the valve. Above this the surface is evenly convex, while below it the valve is flattened. An uncrushed specimen therefore shows in transverse section an outline different from that depicted by Sharpe in his figure 3*b*. It is true that the upper portion of the valve also becomes much flattened in the posterior part of an adult specimen, but only near the siphonal margin. The ribs, starting above at the valve-margin, are directed obliquely backwards, and before the lateral fold is reached they bifurcate, at the same time curving sharply with the convexity backwards directed. An occasional extra, curved rib is here intercalated. Just below the lateral fold the ribs unite again in twos or threes and pass forward in the form of a number of fine, unequally spaced ridges which occupy the lower flattened portion of the valve and run roughly parallel to one another and to the lower margin. In addition to these ridges, the valve below the oblique lateral fold is ornamented by a series of very numerous and crowded, delicate, vertically running raised stripes or wrinkles. This vertical wrinkling is very regular, and occupies the whole of the surface below the lateral fold, crossing the horizontal ridges at right angles. The wrinkles, which number upwards of forty within a space of 10 mm., are developed both on the ridges and interspaces.

*Occurrence*.—Collected in the Zwartkop's River valley, one mile north-east of Rawson Bridge (281). Recorded by Sharpe from the Sunday's River at "C. Roe's drift," and by Stow from above Modder Drift and from M'Loughlin's Bluff, on Sunday's River.

*Remarks*.—The specimens figured by Sharpe, in the collection of the Geological Society, show the vertical wrinklins on the lower portion of the valve, though no mention was made of these. Well-preserved specimens exhibit these structures very clearly, and show that they form a definite part of the sculpture.

The group to which this shell belongs is more characteristic of Jurassic than of Cretaceous rocks. *M. sowerbiana* (d'Orbigny) (= *M. plicata* Sow.),\* a typical Oolitic form, has a much more numerous division of the ribs above the lateral fold, and is rather more curved in outline. *M. perplicata* (Etallon),† from the Upper Jurassic of Europe, is similar in the bifurcation of its ribs; but it attains a greater height in relation to length, and has also a more curved outline. The descriptions and figures of *M. perplicata* ‡

\* d'Orbigny (4), vol. i., pp. 282, 312; J. Sowerby (1), vol. iii., Tab. 248, fig. 1 (1819).

† Thurmann and Etallon (1), p. 223, pl. xxix., fig. 8 (1862); Loriol and Pellat (2), p. 156 (312), pl. xviii., figs. 19, 20.

‡ See also Loriol, Royer, and Tombeck (1), p. 348, pl. xix., figs. 10, 11.

make it clear that the vertical striping on the lower part of the flank is developed in that form also; the same occurs in *M. medus* (d'Orbigny), an allied shell from the Kimeridge.

A shell of very similar type to *M. baini* is *M. flagellifera* (Forbes),\* from the Upper Cretaceous of Europe and Southern India; but an examination of the type specimens in the Geological Society's collection shows that these have the ribs dividing chiefly into groups of three, and the lower part of the flank entirely lacks any traces of the fine vertical stripes.

A fragment of a similarly ornamented, elongated *Modiola* from the Cenomanian of the Sarthe, was considered by d'Orbigny to be specifically distinct from others previously described, and was figured by Guéranger† as *Mytilus sarthensis*. It may be clearly seen from that author's photographic illustration that this differs from *M. baini* by the relatively greater disparity in the number of large and small ribs; in the French shell there are three small ribs to each of the major ribs.

*Modiola rubidgei* (Tate),‡ from the Uitenhage Marine Beds, also bears a general resemblance to *M. baini*. In *M. rubidgei*, however, the ornaments on the upper part of the valve consist of relatively few, gently rounded folds in place of the well-defined narrow rounded ribs in *M. baini*; in addition, these folds are themselves ornamented by finer linear markings which pass backwards along them and then curve forward to run parallel to the lower margin. In *M. rubidgei* there is also an absence of vertical striping on the lower part of the valve.

#### GENUS NUCULA Lamarck.

##### NUCULA UITENHAGENSIS sp. nov.

##### Plate II., fig. 13.

*Description of a Single Specimen.*—The shell is oval in outline, short and high posteriorly, moderately inflated. The cardinal margin slopes down forwards from the umbo with a gently convex outline, and passes by a curve into the rather short anterior margin. The posterior margin falls steeply from the umbo and passes by a rather sharp curve into the long, gently convex inferior margin. The greatest height is at the umbo. The umbonal region is rounded and broad, and not strongly prominent. From the umbo a very faintly developed, blunt ridge of the valve-surface passes forward,

\* Forbes (2), p. 152, pl. xvi., fig. 9; Woods (3), vol. i., p. 99, pl. xvii., figs. 1, 2 (1900).

† Guéranger (1), p. 17, pl. xxiii., fig. 1.

‡ Tate (1), p. 157, pl. ix., fig. 11.



cutting off a narrow, flattened, or slightly concave area contiguous with the cardinal margin. The greatest inflation occurs at about the middle of the valve.

The surface bears numerous closely spaced, delicate, raised, concentric linear ornaments, very weakly developed and indistinct in the umbonal part of the shell, more strongly developed in the inferior half of the valve. These linear ornaments are not produced with perfect regularity, but show occasional inequalities in their spacing, and an occasional coalescence of adjacent lines may be observed, particularly in the posterior part of the valve.

*Dimensions.*—

Length .....	17 mm.
Greatest height .....	11 „
Greatest depth of a single valve .....	5 „

*Occurrence.*—Found by Mr. Rogers in a wash-out 100 feet above Coega station, at a point one mile north of Coega Hotel (441g).

*Remarks.*—The specimen described has both valves in position, and is perfect except posteriorly. When the above description was written the right valve was quite perfect, though the lunular region (in this genus posterior to the umbo) was somewhat obscured by very hard matrix, but an attempt to remove this resulted in slight injury to the valve at the posterior border, so that the margin there is now not quite perfect. Unfortunately a single specimen only was obtained, but it seems to be sufficiently well preserved and well characterised to support the establishment of a new species.

The shell is distinguished by its oval form and rounded, soft outlines. In these respects it bears a considerable resemblance to *Nucula obtusa* J. de C. Sow., from the Upper Greensand and Black-down Beds of England.\*

GENUS GRAMMATODON F. B. Meek and F. V. Hayden.

GRAMMATODON JONESI (Tate).

Plate II., figs. 14, 14a.

1867. *Arca* (*Cucullæa*?) *jonesi* R. Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 161, pl. ix., fig. 9.

*Occurrence.*—Collected by Miss M. Wilman at Coega. This shell is also recorded by Messrs. Rogers and Schwarz as occurring in the highest of three beds of sandstone on the Grass Ridge road near Uitenhage.† The specimens described by Tate occurred “in a

\* Woods (3), vol. i., p. 22, pl. iv., figs. 2, 3, 4 (1899).

† Rogers and Schwarz (1), p. 9.

greenish-grey sandy marl, rather hard and very calcareous, near the Bridge on the Zwartkop River."

Dimensions.—	(1)	(2)	(3)	(4)
Length .....	13	18	21	22 mm.
Height .....	9	12	14	13 „
Depth of a single valve	4	—	6	— „

No. (2) is Tate's figured specimen.

*Remarks.*—This form is closely similar in general type to *G. securis* (Leym.) \* (Lower Cretaceous) and *G. carinatus* (Sow.) † (Gault and Upper Greensand), and although I have been unable to ascertain the characters of the hinge, the close agreement in form and ornamentation is perhaps sufficient justification for classing this shell in the same generic group of the Arcidæ. In the use of the name *Grammatodon* I follow Mr. Woods.‡

Compared with *G. securis*, our shell is found to differ by the considerably finer and more closely spaced ribs on the flank of the left valve. With regard to the ribbing, there is greater similarity to *G. carinatus*, but this, on the whole, is a decidedly more equilateral shell, although specimens might be selected which in most respects closely approach *G. jonesi*. *G. carinatus* frequently attains much larger dimensions, with a proportionately coarser development of the ornaments, than *G. jonesi*. A shell of similar type, and perhaps related to *G. jonesi*, occurs in the Lower Neocomian beds of German East Africa, which were correlated by G. Müller with the Uitenhage Series. Müller described and figured this under the name *Arca uitenhagensis*,§ and drew attention to the apparent relationship to *Arca jonesi* Tate. *A. uitenhagensis*, which is associated with *Trigonia ventricosa* (Krauss) and *T. beyschlagi* Müller, differs from *Grammatodon jonesi* by the fewer number and much greater breadth of its ribs.

#### GENUS UNIO A. J. Retzius.

#### UNIO UITENHAGENSIS sp. nov.

Plate II., figs. 15, 15a.

*Description.*—The shell is of elongated oval outline, posteriorly produced, and laterally compressed in the postero-inferior region of

\* Leymerie (2), p. 6, pl. vii., figs. 6, 7; Woods (3), vol. i., part 1, p. 44, pl. vii., figs. 14, 15, pl. viii., figs. 1, 2 (1899).

† J. Sowerby (1), vol. i., p. 96, Tab. 44, lower figure (1813); Woods (3), vol. i., p. 45, pl. viii., figs. 3-8 (1899).

‡ Woods (2).

§ G. Müller (1), p. 542, pl. xxv., fig. 5. [This name seems very unhappily chosen.]



the adult. The umbones are situated at almost one-third of the shell's total length from the anterior extremity. The umbonal region is relatively very inconspicuous, and of blunt, rounded form. The shell-substance is for the most part very thick, but becomes attenuated at the pallial margin. The upper margin in front of the umbo passes by a curve into the rather short, convex anterior border. The posterior margin merges into the upper margin and slopes obliquely back, to pass by an abrupt curve into the inferior margin.

The greatest height is at the umbo, and the greatest inflation, which is relatively weak, occurs below the umbonal region, in the superior half of an adult individual. About the middle of the shell near the pallial margin the valves appear slightly constricted, as though laterally pinched in. The surface is marked by numerous noticeable furrows and ridges of accretion.

<i>Dimensions.</i> —	(1)	(2)
Greatest length .....	37	43 mm.
Greatest height .....	21	23 „
Greatest depth of a single valve	7	8 „

*Occurrence.*—In a hard calcareous band in the rocks of Atherstone's "Wood Bed" series, on the north bank of the Bezuidenhout's River below Blue Cliff station (322, 323).

*Remarks.*—The shells still retain traces of the strong periostracum, and the elongated external ligament is also in part preserved. This is apparently the form cited by Messrs. Rogers and Schwarz as *Psammobia*,\* and such a generic determination might appear to receive some support from the elongated oval figure of the shell, the inconspicuous umbones, the relatively compressed aspect of the valves, and the lengthened external ligament. The valves, however, are very thick, and this character, as well as the wrinkled surface and the blunt and obviously corroded umbones, proclaims another generic position; moreover, the pallial line is entire. In the shell-structure, also, although this has become obliterated in its intimate characters through replacement by calcite, it can be clearly observed that a line of demarcation separates a thin outer layer, representing the original prismatic layer, from the relatively thick inner portion, formerly consisting of nacreous substance.

This form differs from *Unio porrectus* J. de C. Sow.,† from the Wealden, by the less strongly elongated outline and the much less tapering posterior extremity. *Unio antiquus* J. de C. Sow.

\* Rogers and Schwarz (1), p. 13.

† J. de C. Sowerby (1), vol. vi., Tab. 594, fig. 1 (1828).

(Wealden) \* is rather less equilateral, the umbonal region is more prominent, and the antero-superior border more steeply sloping.

*Unio martini* J. de C. Sow. (Wealden) † is more equilateral, much higher and less slender in figure, and probably a more inflated form.

*Unio subsinuata* Koch and Dunker, ‡ from the Wealden of North Germany, is in some respects similar, notably in the form of the posterior half of the shell and the position of the umbones, but differs markedly in the horizontally produced superior margin in front of the umbones. *Unio voltzi* Koch and Dunker, § though regarded by those authors as distinct from the last, differs in similar manner from *Unio uitenhagensis*. *Unio planus* Roem. || is more compressed in form and has a less sloping antero-superior outline.

A comparison with the figures and descriptions of the forms of *Unio* from the Jurassic and Cretaceous rocks of North America does not show that resemblances exist which call for special remark.

# GENUS TRIGONIA J. G. Bruguière.

## TRIGONIA VENTRICOSA (Krauss).

### Plate III., figs. 1, 1a.

1843. *Lyriodon ventricosa* F. Krauss, Amtlicher Bericht über die zwanzigste Versammlung der Gesellsch. deutsch. Naturforscher und Aerzte zu Mainz im Sept., 1842, p. 130.
1850. *Lyrodon ventricosus* F. Krauss (*partim*), Nov. Act. Acad. Cæs. Leop.-Carol. Nat. Cur., vol. xxii., pt. 2, p. 456, Tab. 49, figs. 2c-2f, (exclude figs. 2a, 2b).
1871. *Trigonia ventricosa* F. Stoliczka, Cretaceous Fauna of Southern India, vol. iii., The Pelecypoda; p. 315, pl. xv., figs. 9. 9a. (Palæontologia Indica.)
1875. *Trigonia ventricosa* J. Lycett, Mon. Brit. Foss. Trigoniæ, p. 119, and text-figures. (Palæontographical Society.)
1877. *Trigonia ventricosa* O. Feistmantel, Foss. Flora of the Gondwana System, vol. i., pt. 3, p. 164. (Palæontologia Indica.)

\* J. de C. Sowerby (1), vol. vi., Tab. 594, figs. 3-5 (1828).

† J. de C. Sowerby (2), p. 346, pl. xxi., fig. 17.

‡ Koch and Dunker (1), p. 58, Tab. vii., fig. 2; Dunker and Meyer (1), p. 26, Taf. xi., figs. 4, 5.

§ Koch and Dunker (1), p. 59, Tab. vii., fig. 3.

|| F. A. Roemer (1), p. 95, Taf. v., fig. 14; Dunker and Meyer (1), p. 27, Taf. xi., fig. 8.



1879. *Trigonia ventricosa* W. T. Blanford, in Medlicott and Blanford, Manual of the Geology of India, pt. 1, p. 261, with text-figure.
1880. *Trigonia ventricosa* O. Feistmantel, Foss. Flora of the Gondwana System, vol. ii., p. xxxvii. (Palæontologia Indica.)
1893. *Trigonia ventricosa* W. T. Blanford, in Medlicott and Blanford, Manual of the Geology of India (2nd edition revised and partly rewritten by R. D. Oldham), p. 225, with figure.
1900. *Trigonia ventricosa* G. Müller, Verstein. des Jura und der Kreide. Deutsch-Ost-Afrika, Band vii., p. 543, Taf. xix., figs. 4, 5.
1903. *Trigonia ventricosa* F. L. Kitchin, Jurassic Fauna of Cutch, vol. iii., pt. 2, The Lamellibranchiata; p. 104, pl. x., figs. 4-8. (Palæontologia Indica, Ser. IX.)
1905. *Trigonia ventricosa* A. W. Rogers, An Introduction to the Geology of Cape Colony, p. 291, fig. 25 (2).

*Occurrence.*—This widely distributed and very characteristic form occurs in the Marine Beds at various localities on the Sunday's and Zwartkop's Rivers. It was collected by Messrs. Rogers and Schwarz at a kloof on the left side of the Zwartkop's River, east-north-east of Red House (308), and was found to occur abundantly in a cliff at "Picnic Bush"; it is also cited from localities in the neighbourhood of Uitenhage, on the road to the top of Grass Ridge and in the railway cutting between milestones  $24\frac{1}{2}$ — $24\frac{3}{4}$  on the Graaff-Reinet railway, about three miles from Uitenhage.\* Mr. Rogers collected it on the left side of Coega Valley, half a mile down from the railway (463g), and in a small kloof three miles up the left bank of Sunday's River (14h, 15h). Stow remarked upon the great abundance of this shell in the cliff at "M'Loughlin's Bluff" or "Prince Alfred's Rest" on the Sunday's River. † Krauss found it in the left bank of Zwartkop's River below Uitenhage, associated with *Trigonia herzogii* and *T. conocardiiformis*.

In German East Africa, shells referred to this species have been found in strata ascribed by G. Müller to the Lower Neocomian and brought by him into relationship with the Uitenhage beds, at a locality a short distance to the north of the Nkundi stream, 29 km. north-west of Kiswere. There they occur with *Trigonia beyschlagi*, which shows strong resemblance to *T. crassa* Kitchin, from the Oomia marine beds in Cutch.

\* Rogers and Schwarz (1), pp. 8-10.

† Stow (1), p. 502.

In India, *T. ventricosa* occurs numerously at various localities in the marine beds of the Oomia Group in Cutch, notably in the neighbourhood of Oomia and Goonaree; it is also stated to have been found by King in an outlier of the Tripetty beds at Innaparazpolliam, to the north-west of Coconada on the south-eastern side of the Indian peninsula.\* It is recorded, too, from the Margalla Pass in the district of Hazara, where it is said to occur in abundance.†

*Remarks.*—*Trigonia ventricosa* bears a general resemblance to members of the *aliformis* group of the section Scabræ, particularly to *T. aliformis* Park.,‡ with which it was confounded by von Buch, and to *T. scabricola* Lycett; § but the relative shortness and great height of the outline, the very strong anterior inflation, and the coarse and salient character of the ornaments on the anterior part of the adult shell, serve to separate it from all known members of the section in Europe. It has been repeatedly pointed out that much closer agreement is shown to *T. tuberculifera* Stoliczka, from a higher horizon in the Cretaceous rocks of Southern India. The resemblance appears to be remarkably great, but unfortunately Stoliczka's description and figures of *T. tuberculifera* leave something to be desired. I have elsewhere drawn attention to the fact that in the figure of the front view of Stoliczka's type || the ribs of the right and left valve are represented as though placed opposite to one another at their frontal terminations; in *T. ventricosa*, on the other hand, as in other members of the section, these ribs alternate in position, and it seems probable that an error was committed in the execution of this figure of *T. tuberculifera*.

A comparison of *T. ventricosa* with *T. kraussi* sp. nov. will be found in the remarks appended to the description of the latter.

*T. subventricosa* Stanton, from the Belgrano beds of the Pueyrrydon Series in Patagonia,¶ so far as can be gathered from the description and figures of that shell, is of very similar type, but seems to be less strongly inflated, and to be of relatively more elongated form.

*T. delafosei* Bayle and Coquand,\*\* from the Neocomian of Chili, also shows a general agreement with *T. ventricosa*, and may

\* King (1), p. 229; Feistmantel (2), p. 164; Feistmantel (3), p. xxxvii.

† Wynne (2), p. 125; Medlicott and Blanford (1), p. 503.

‡ Parkinson (1), p. 176, pl. xii., fig. 9; Lycett (3), p. 116, pl. xxv., figs. 3-6 (1875).

§ Lycett (3), p. 130, pl. xxvii., figs. 4, 5.

|| Stoliczka (2), pl. xv., fig. 10 (1871). ¶ Stanton (3), p. 18, pl. iv., figs. 19, 20.

\*\* Bayle and Coquand (1), p. 37, pl. viii., fig. 27; R. A. Philippi (1), p. 85, pl. xxxvi., fig. 4; Paulcke (1), p. 296, Taf. xvii., fig. 9.



perhaps be closely related. It appears, however, to have more closely spaced and less coarsely nodose ribs. To judge from the description and figures of *T. delafosei* given by Paulcke, the escutcheon is more sharply demarcated from the area than in *T. ventricosa*; *T. delafosei* also does not appear to have attained such large dimensions. Another South American form, *T. nepos* Paulcke, from the Neocomian of Chili, shows to some extent a similarity to *T. ventricosa*, especially if the smaller individuals figured by Paulcke\* be compared with specimens of similar size; *T. nepos*, however, has more delicate sculpture and is also well distinguished by the peculiar arrangement of the ribs towards the frontal face. In the work cited above, Paulcke brings *T. nepos* and *T. delafosei* into close relationship; yet he perceives in *T. nepos* an exceedingly close resemblance to *T. baylei* Dollfus,† from the Kimeridge of Europe, and recognises in the similarity an indication of the scaphoid ancestry of these Cretaceous forms. It may be pointed out that the principal character upon which he relies, the existence of a more or less independent series of anterior ribs, is a feature to which, alone, such significance can certainly not be attached. It represents a plan of sculpture which has appeared repeatedly and independently in various *Trigonia*-stocks, and in *T. baylei* and other typical Jurassic Scaphoideæ is associated with well-marked characteristics which indicate the very high improbability of such direct relationship as that suggested. In *T. ventricosa*, *T. delafosei*, and *T. nepos*, just as in the *T. aliformis* group of Europe, the very prominent and highly inflated umbonal region, the extreme incurvation of the umbones, the relatively very narrow area and the crenulation of the shell margin, are characters which are conspicuously developed in these well-marked and specialised groups. In *T. baylei* and similar Scaphoideæ, the laterally compressed form, the weak umbonal incurvation, the nodose carinæ and delicately sculptured area, no less than the relations of frontal to lateral costæ, are also characters of specialisation, and judging by the evidence of early growth-stages, these shells had ancestry in simple clavellate forms. A similar though independent ancestry seems also very probable in the case of the various groups classed under the broad heading Scabræ.

In the published description of the *Trigonia* from the Oomia Group in Cutch, it is stated that the Indian specimens ascribed to *T. ventricosa* "although exhibiting great variability, offer no features

\* Paulcke (1), p. 293, Taf. xvii., fig. 8.

† Dollfus (1), pl. xv.; Bigot (1), p. 309 [51], pl. xii., fig. 10.

except their state of preservation by which they may be distinguished from those occurring in South Africa."\* Having due regard to the range of individual variation shown by the specimens which occur in the Oomia beds, I believed this statement to be quite accurate, but a reconsideration of this matter and a renewed comparison between a larger number of specimens now necessitates a slight modification. While it is seen that the limits of individual variation among the Indian specimens cover differences greater than those to be observed between the average characters shown by examples of the species from the one region and those from the other, it should be noted that in India many of these shells exhibit a somewhat less degree of inflation than that seen in most of the South African examples. The specimens from Cutch sometimes have the tubercular ornaments rather more prominently developed, though in certain cases the effect of prominence seems to have been enhanced by the mode of preservation of the shells. There is also a tendency to have the tubercles less closely crowded together and less regularly moniliform than in the specimens from South Africa. It is difficult to say in how far these characters may have been the product of strictly local conditions. There certainly appears to have been a greater range of individual variation and greater instability than is shown by the specimens from the Uitenhage beds. At the same time, the agreement between a selected series of specimens from the one region and a suite of individuals from the other is remarkably close, and, all things considered, I do not think that the points of difference, above noted, suffice for the establishment of two separate species, or, indeed, even for the satisfactory recognition of two well-defined local races.

TRIGONIA KRAUSSI sp. nov.

Plate III., figs. 2, 2a.

1850. *Lyrodon ventricosus* F. Krauss (*partim*), Nov. Act. Acad. Cæs. Leop.-Carol. Nat. Cur., vol. xxii., pt. 2, Tab. 49, figs. 2a, 2b (exclude figs. 2c-2f).

*Description*.—The shell is relatively short, anteriorly very high, with the upper and lower margins rapidly converging posteriorly towards the very short siphonal margin. The valves are anteriorly very strongly inflated, but posteriorly compressed. The umbones are prominent, strongly incurved and markedly recurved, and situated close to the anterior end. The greatest height is attained

\* Kitchin (1), p. 107.

at the umbo, and may exceed the total length. The valve is almost vertically truncated anteriorly and in its anterior part attains such relatively great depth that a flattened frontal face of considerable extent becomes developed.

In the youthful stage the ribs of the flank are concentric in arrangement, extending from the carinal angle to the frontal border. As growth proceeds, subsequently formed ribs terminate anteriorly at the frontal border but posteriorly at an increasing distance from the carinal angle. The ribs at the same time attain a more steeply inclined direction, and the last-formed rib of the frontal series is very short and almost vertical. In the early adult stage narrow, closely spaced ribs extend between the carinal angle and the upper terminations of the swollen frontal ribs, or may be looked upon as the attenuated upward prolongations of these since the two sets are so far in continuity. Successively formed narrow ribs, constituting a posterior series, have their upward terminations slightly removed from the carinal angle, and in the posterior half of a fully grown specimen these crowded ribs of the posterior series entirely occupy the flank. The ribs of the anterior series are very prominent and coarsely tubercular, and may be elevated to a height of 7 or 8 mm. above the surface of the interspaces. These ribs are very widely spaced, the interspaces reaching 8 mm. in breadth in the adult stage; on the frontal face the ribs sweep round in a broad curve towards the anterior valve-margin. The development of the earlier-formed ribs is not continued in the later growth-stages, so that in a large specimen the frontal face is partly without sculpture in its upper part, towards the valve-border. The ribs of the posterior series are at first vertically directed, but the majority of them have a marked backward inclination when traced downwards. They are relatively weak, and are separated by interspaces less than 2 mm. in breadth. The whole surface of the flank is crossed by crowded lines of growth which are most plainly visible in the wide interspaces between ribs of the anterior series.

The carinal angle is represented by a blunt, rounded fold in the adult shell. The area is very narrow, and is without ornamentation in the adult stage, except a strongly impressed median longitudinal groove. The escutcheon is relatively broad and is deeply excavated in form.

*Dimensions.*—

Length (approximate).....	75 mm.
Height measured from the umbonal region .....	82 „
Greatest depth of a single valve.....	45 „



*Occurrence.*—Messrs. Rogers and Schwarz record the occurrence of this shell ("the large variety of *T. ventricosa*") \* in the railway cutting between milestones 24 $\frac{1}{2}$ –24 $\frac{3}{4}$  on the line from Uitenhage to Graaff-Reinet, about three miles from Uitenhage. The specimen from the South African Museum, here figured, is probably from the Sunday's River. Krauss met with this form in the left bank of the Zwartkop's River below Uitenhage.

*Remarks.*—This characteristic *Trigonia*, which belongs to the section *Scabræ*, may be said to exhibit in very exaggerated manner some of the most striking features which render *T. ventricosa* (Krauss) so conspicuous amongst the members of this section. *T. ventricosa*, though so well distinguished by its form and ornamentation, is in some respects comparable with the European *T. scabricola* Lycett or *T. aliformis* Park., and was even considered identical with the latter by L. von Buch.† *T. kraussi* is so far removed from European members of the section that a detailed comparison with these is unnecessary, and it only remains to draw attention to the characters which differentiate it from *T. ventricosa* and the apparently closely allied *T. subventricosa* which occurs in the Belgrano beds of Patagonia.

*T. kraussi* is principally distinguished by its large size and the very prominent character and wide spacing of the anterior ribs. Another striking feature is the great anterior inflation and extensive flattened frontal face. In other respects the resemblance to *T. ventricosa* is so great that I was led to ask Mr. Rogers whether he was aware of the existence of specimens intermediate in character between the extremes; his reply, however, was in the negative. So many specimens of *T. ventricosa* have been obtained by various collectors, and the Uitenhage *Trigoniæ* are so well represented in European museums that we might certainly expect to find intermediate forms, if such existed, in some of the collections. No specimens connecting the extreme forms appear to have been found, and amongst the *Trigoniæ* of the Oomia beds in Cutch the representatives of *T. ventricosa*, met with in abundance, agree with the smaller typical form in South Africa.

*T. kraussi* has approximately double the dimensions of *T. ventricosa*, but is, perhaps, slightly shorter relatively to height. The number of anterior ribs formed in the youthful and early adult stages may perhaps be not widely different, but the spacing of the ribs rapidly widens in the larger form, and the interspaces may reach 8 mm. in

\* Rogers and Schwarz (1), p. 10.

† von Buch (1), p. 23.

width. In the adult *T. kraussi*, within a space of 33 mm. measured backwards along the flank from the lower end of the frontal margin, three ribs only are included. At a height, measured from the umbo, which represents the full adult height of *T. ventricosa*, the anterior ribs on the flank of *T. kraussi* are already much more robust and more widely spaced than in *T. ventricosa*. The anterior inflation is also much stronger. These very well-marked differences in characters developed at a comparable stage in the two forms lead me to separate definitely *T. kraussi* from *T. ventricosa*. It may well be the case that we are here dealing with two branches of a not far removed ancestral stock, both of which have evolved along similar lines, but one more rapidly than the other. The more advanced type may be recognised in *T. kraussi*, from the fact that it exhibits all the late adult characters of *T. ventricosa* while yet in the early adult stage itself; the late adult characters of *T. kraussi* are never reached in *T. ventricosa*. It is highly improbable, indeed, that this giant form merely represents extreme individual variation in *T. ventricosa*, and its separation from this seems to me to be justified.

There is a close general agreement with *T. subventricosa* Stanton,\* especially in the large dimensions, but the Patagonian shell is relatively more elongated, has the valves less strongly inflated, and the flattened frontal face less extensively developed. In *T. kraussi* the umbonal region is more narrowed in form and considerably more prominent, taking Dr. Stanton's figure to represent a typical specimen of the Patagonian shell.

Both *T. ventricosa* and *T. kraussi* are figured by Krauss as representatives of the same form, and he makes no mention of the differences to which I have above alluded, though these are plainly shown in the figures which accompany his description of *T. ventricosa*. In deciding which of Krauss's specimens are to bear the name *T. ventricosa* it is well to note that his description more accurately applies to the small specimens, and it may further be observed that when he spoke of the species as "particularly numerous" represented he must have referred to the smaller form. This alone has been abundantly collected and it has also been frequently spoken of in the literature under the name *T. ventricosa*. Moreover, no less than six authors have figured the smaller shells under the name given by Krauss.

\* Stanton (3), p. 18, pl. iv., figs. 19, 20



TRIGONIA ROGERSI sp. nov.

Plate III., figs. 3, 3a ; IV., fig. 1 ; V., fig. 2.

*Description.*—The shell is of somewhat elongated form; it is anteriorly high and is posteriorly more slender in outline and considerably produced. The valves are moderately inflated in the anterior half of the shell, and are posteriorly more compressed. Anteriorly, the surface of the valve curves round towards the frontal margin so as to give the shell some appearance of anterior flattening or even truncation, most marked in specimens of large size. The umbones are situated at about one-quarter of the total length from the anterior extremity. They are prominent, well incurved, and slightly recurved. The cardinal margin slopes down gradually, forming a long, almost straight outline, and passes by a rather abrupt curve into the short, convex posterior border. In front of the umbo the valve margin falls steeply at once to form the lengthy frontal border, gently and regularly convex in outline, which passes by a regular and broad curve, without break, into the lower border. This in turn has a gently convex outline, and slopes up gradually towards the posterior margin. The greatest height falls at the umbo.

The costæ of the flank are concentric in arrangement until the close of the neanic stage, becoming then more and more downwardly inclined, when traced from their commencement at the carinal angle. In an adult specimen the ribs in the anterior third of the shell are not at all curved in form as they pass obliquely down the flank, but on the frontal face of the valve they curve rapidly so as to approach the frontal margin horizontally. The successive costæ are more and more steeply directed until at about the middle of the valve their direction is vertical. Posteriorly to this they have a very slight backward inclination. The ribs in the anterior, inflated part of the shell are prominent, strongly nodose or tubercular, and are separated by interspaces as broad as the ribs themselves; on the frontal face the interspaces are much wider. The ribs of the posterior half of the shell are narrower and less prominent in character, are only weakly nodose, and are more closely crowded together. In a large individual, about a dozen large, prominent ribs may be counted in the anterior part of the valve. In the early adult period, occasional short rows of delicate nodes of unequal extent may be intercalated on the surface between the main ribs where these approach the valve margin on the frontal face. On the surface of the valves clearly marked lines of growth are well seen as they cross the interspaces, but are either little conspicuous or absent on



the tubercles of the ribs. In the largest individuals, characters of senility are seen in the imperfect rib-formation near the lower margin, and the replacement of sculpture by simple ridges and lines of accretion at the frontal margin, where the ribs may then be seen to terminate at some little distance from the actual margin.

For a distance of about 15 mm. from the umbonal apex a very delicately nodose, narrow marginal carina is present. It then dwindles abruptly and disappears, while the carinal angle becomes less marked when traced posteriorly and is replaced ultimately by a gentle and rounded fold of the valve surface.

The area is very narrow anteriorly, and gradually broadens posteriorly. For a distance of about 15 mm. from the umbonal apex it is ornamented by delicate, slightly granular, transverse ridges separated by narrow grooves. The terminations of these ridges at the carinal angle do not correspond strictly with the upper terminations of the ribs on the flank, but the ridges on the area are rather more numerous than these. Each of the ridges terminates inwardly in a delicate, transversely elongated node, a row of which takes the place of an inner carina. At a distance greater than 15 mm. from the umbonal apex the area is without sculpture, though two or three further inner-carinal nodes may be present. The area is divided by a well-marked longitudinal groove into a narrower, superior, and broader inferior portion. The groove is continued right to the posterior margin. At the posterior end of a specimen measuring 84 mm. in length, the area is about 20 mm. in breadth. The escutcheon is of great size and length, and at the middle of the shell it is much wider than the area. In its anterior half it is of well-excavated, concave form. Its ornaments consist of numerous, fine, beaded ridges or lines of delicate nodes passing from the inner-carinal nodes rather obliquely backwards across to the cardinal margin. At 30 mm. from the umbonal apex these ornamenting lines cease to be formed, and several of them situated posteriorly in the series do not extend to the cardinal margin. Posteriorly, the inner carinal ridge of the valve becomes obsolete and the smooth escutcheon ill-defined. The ligament space is relatively long, measuring 18 mm. in length in a specimen having a length of 84 mm. In each valve it shows at the cardinal margin a straight lath-like ridge, becoming gradually thinner when traced back from the umbo, separated from the escutcheon by a straight, deep, narrow groove.

The central tooth of the left valve is of relatively great size and prominence, and its inferior indentation is deep. The inner surface

of the valve margin is smooth, in the anterior part of the shell at least. If there is any crenulation at all, it is confined to the posterior half of the valve, and must be of a weak description.

<i>Dimensions.</i> —	(1)	(2)	(3)
Length (estimated) .....	78	84	135 mm.
Greatest height .....	53	58	92 „
Greatest depth of a single valve	19	23	32 „

*Occurrence.*—Obtained by Mr. Rogers from a bare slope W. 30 S. from the middle of Barkly Bridge, on the farm Olifant's Kop, Sunday's River (20h); also from Coega Valley, east of the railway, one mile up the line from Coega station (472g).

*Remarks.*—This is an elongated representative of the section *Scabræ*, and, generally speaking, it exhibits the normal characters of the section. It is remarkable, however, for its very large size and for the manner in which it shares the character of posterior elongation with other *Trigoniæ* from the Uitenhage beds and from the *Oomia* beds of Cutch. This prolongation at the siphonal end, and the absence of sculpture from the area in the later adult stages are characters similarly shown in members of the group of *Trigonia vau* and in *T. conocardiiformis* (Uitenhage Series) and in members of the group of *T. v-scripta* and certain degenerate *Costatæ* (in the *Oomia* beds). There are evidences of degeneracy in all these forms. In the specimen numbered (2) in the above table of measurements, one valve is almost complete at the siphonal border, and the form of the valve at that part suggests that in the complete shell a slight posterior gape may have been developed, just as in *T. stowi*.

In the neanic and early adult stages, *T. rogersi* bears a considerable resemblance to the same stages in *T. ventricosa* (Krauss). It differs, however, in details of the sculpture on the area and escutcheon, and with advancing growth, the characters of outline, degree of inflation, and ribbing of the shell are so widely distinct in the two forms as to need no comparison here.

#### TRIGONIA HERZOGI (Goldfuss).

Plate V., fig. 1.

1837. *Lyrodon herzogii* (Hausmann) A. Goldfuss, *Petrefacta Germaniæ*, Band ii., Lief. 6, p. 202, Tab. cxxxvii., fig. 5.

1850. *Lyrodon herzogii* F. Krauss, *Nov. Act. Acad. Cæs. Leop.-Carol. Nat. Cur.*, vol. xxii., pt. 2, p. 453, Tab. 48, fig. 3.

1882. *Trigonia herzogi* G. Steinmann, Neues Jahrbuch für Mineralogie, Band i., p. 220, Taf. vii., figs. 1, 2; Taf. ix., figs. 1, 2.

*Occurrence.*—This is an abundant and characteristic form in the Sunday's River Beds. It was recorded by Hausmann from the neighbourhood of Enon, and by Krauss from the left bank of the Zwartkop's River below Uitenhage; also by Stow\* from various localities on the Sunday's and Zwartkop's Rivers. A fine specimen sent to me from the South African Museum is from the Sunday's River (289). Messrs. Rogers and Schwarz found *T. herzogi* on the north side of the Zwartkop's River at a locality to the west of Rawson Bridge, and at Picnic Bush; also further up the river on the road from Perseverance Farm to the Salt Pan, and at Cuyler Manor. Near Uitenhage, they record this form from two beds of sandstone exposed in dry watercourses on the ascent of the Grass Ridge road; in the railway cutting between milestones  $24\frac{1}{2}$ – $24\frac{3}{4}$  on the Graaff-Reinet railway; and on the road to Hillwacht, where the path leaves the plain. On the Sunday's River it was found near the top of the white krantz on Wolve Kraal, on the north bank of the river.

The collection made in 1905 by Mr. Rogers includes several specimens of *T. herzogi*, which came from the following localities: the left side of Coega Valley, two miles down from the railway (468g); from the valley east of the railway, one mile up the line from Coega station (474g); the cliff on Buck Kraal, Sunday's River (116h, 120h, 122h); and the cliffs on Zoet Geneugd, Sunday's River (99h).

*Remarks.*—*Trigonia herzogi* is well known from the striking figure given by Goldfuss, illustrating a fine specimen which was included in a small collection of Uitenhage molluscs obtained by Hertzog. These had been previously noticed briefly by Hausmann in his paper on the geology of South Africa.† The shell is conspicuous for its large size and elongated outline, its straight and lengthened cardinal margin and its straight, nodose ribs, backwardly inclined in the posterior half of a fully grown valve. It was referred by Pictet and by Lycett to the section Quadratae. An excellent figure of the shell was given also by Steinmann, who included *T. herzogi* with *T. transitoria* Steinm. in the group Pseudo-quadratae, the characters of which are briefly discussed below in the remarks appended to the description of *Trigonia holubi*. Steinmann has set forth in great detail the differences that distinguish *T. herzogi* from

\* Stow (1), pp. 498–505.

† Hausmann (1), p. 1458.



*T. transitoria*, which occurs in Neocomian strata in Bolivia, Chili, and the Argentine Republic. *T. transitoria* shows a closer approximation of characters to the Clavellatæ; it is not so elongated in outline, and its strongly nodose ribs have a curved form and a forward sweep when traced downwards, throughout almost the whole extent of the flank. In *T. transitoria* the rows of nodes representing the marginal and median carinæ become joined by transverse rounded ridges at an earlier growth-stage than in *T. herzogi*, in which these rows of nodes, and that representing the inner carina, remain isolated and distinctly developed until traced farther back towards the siphonal margin of a fully grown individual. The escutcheon is smooth in its anterior part in *T. transitoria*, while ornamented at an early stage in the African shell; in *T. transitoria* the escutcheon, generally speaking, is more sparsely sculptured.

I have elsewhere pointed out the features of distinction between *T. herzogi* and *T. mamillata*, from the Oomia beds of Cutch.\* *T. mamillata* shares the principal characters of the Pseudo-quadratae, but is a shorter shell than *T. herzogi*, and is vertically truncated in front. In *T. mamillata* those ribs situated at the centre of the flank, and posteriorly to this, are slightly curved, and are directed anteriorly at their lower ends, while the corresponding ribs of *T. herzogi* are backwardly directed and are not curved. On the area of *T. mamillata*, the rows of more or less isolated nodes become united to form smooth transverse ribs nearer to the umbo than in the African form, in which, also, the lines of nodes and transverse ridges of the area are rather more closely spaced. In *T. mamillata* the tubercles are more closely crowded together in the ribs of the flank and are, generally speaking, more robust and conspicuous than in *T. herzogi*, particularly in relation to the size of the valve. The blunt transverse ridges of the area towards the posterior end of an adult specimen are broader and more strongly developed than in *T. herzogi*.

A comparison with *Trigonia holubi* is given in the remarks which follow the description of that form.

Two specimens depicted in the left-hand side of a text-figure published by Drs. Hatch and Corstorphine† represent *T. herzogi*, but very greatly reduced in size.

#### TRIGONIA HOLUBI sp. nov.

Plate IV., figs. 2, 2a.

*Description.*—The shell is large and massive, almost oblong in outline, and usually vertically truncated in front, or with very steep

\* Kitchin (1), p. 102.

† Hatch and Corstorphine (1), p. 245, fig. 66.

forward obliquity; the length is greater than the height. The nearly terminal umbones are little conspicuous and weakly incurved. The cardinal margin forms an almost straight line and slopes back very gently from the umbo. It forms posteriorly a sub-angular junction with the relatively long, slightly convex siphonal margin. The frontal margin is very slightly convex, more seldom quite straight, in outline, and passes below by a sharp curve or sub-angular junction into the lower border; this is more convex in profile. The inflation of the valves is relatively weak; the greatest height occurs at about the middle of the valve. A flattened frontal face is well developed in fully grown specimens. There is no definite carinal angle, but the area is well demarcated by the limits of its particular sculpture, which is contrasted with that of the flank.

The sculpture of the flank in the young shell consists of relatively strong concentric nodular ribs, four of which are already developed when the shell has attained a height of 10 mm. Subsequently formed ribs increase rapidly in prominence and robustness and become steeply inclined, so that after about ten ribs are developed all reach the inferior margin. The ribs of the adult shell consist of rows of large and prominent tubercles, some of which reach a diameter of 5 mm. Most of the ribs have a forward sweep when traced downwards; an approximately vertical direction is attained only by those ribs situated in the posterior half of a fully grown valve, and these also are slightly curved in form, with the convex side directed posteriorly. The interspaces are rather narrower than the tubercles of the ribs. In the early and middle adult stages, the tubercles composing the ribs are well separated from one another on a given rib. In the late adult and senile stages the tubercles become closely crowded together and are contiguous. Towards the lower border of a fully grown individual the tubercles tend to become elongated in a direction parallel to the shell margin, and they may appear to coalesce with prominent ridges of growth. With senility the ribs become imperfectly developed, while crowded ridges and furrows of growth are more marked near the pallial margin. In the lower half of the anterior portion of the flank in an adult specimen some tubercles are somewhat unevenly dispersed, giving rise to an appearance of irregularity, with departure from the strictly linear arrangement. In a fully grown specimen about sixteen ribs are developed on the flank.

The area in the neanic stage is crossed by transverse ribs continuous with those of the flank. In the early and middle adult stages no ribs are developed upon it; but a line of tubercles limits

the area above, a second row of less well-defined tubercles is situated just below the longitudinal groove, while a third row of well-spaced stronger tubercles limits the area below. Prominent transverse ridges or irregular ribs cross the area in the posterior half of an adult individual, terminating above and below in the marginal tubercles and also between them. These ridges make their first appearance somewhat abruptly, and become more strongly marked and also more irregular in their form and spacing towards the posterior end of the area, in a well-grown individual. A few may even pass over to the flank and be there partly identified with ridges of growth. The longitudinal groove of the area, which divides it into a narrower, superior, and broader inferior portion, forms a constriction in each transverse ridge.

The escutcheon is narrow and relatively very elongated. It is ornamented by irregular rows of coarse tubercles or prominent ridges which pass very obliquely across its surface and terminate anteriorly at the cardinal margin. They are seen to be frequently continuous with the ornaments of the area. The ligament pit is of narrow and elongated lanceolate form, and in a large individual extends to half the length of the escutcheon.

The central tooth of the left valve is very massive and prominent, with relatively narrow apical angle. The anterior tooth of the right valve is supported by a well-raised platform. At the posterior end of the valves the raised ridge on the internal surface which separates the siphonal channels is situated high up in the siphonal border and is of relatively great strength and extent; in a fully grown individual it can be traced for at least 25 mm. from the margin.

<i>Dimensions.</i> —	(1)	(2)	(3)	(4)
Length (about) .....	98	. 110	. 120	. 132 mm.
Greatest height .....	75	. 78	. 87	. 88 „
Depth of a single valve	18	. 20	. 22	. 25 „

*Occurrence.*—Specimens in the collection of the South African Museum came from the Sunday's River (285 to 288, 290 to 296, 299). Mr. Rogers collected this form on the left side of Coega Valley, half a mile down from the railway (458g). An immature specimen from Brentford, Knysna Estuary (150h), is also probably referable to *T. holubi*.

*Remarks.*—The characters of this shell appear to be on the whole very well defined, while the valves are especially conspicuous both by their large dimensions and their salient ornamentation. Most of the specimens submitted to me, in all of which the shell is replaced by coarsely crystalline calcite, have had the surface considerably



corroded by weathering. In these specimens the etching has attacked the shell along lines of weakness, and has brought the tubercles and ornamenting ridges into undue relief, which results in an appearance so deceptive that for some time I was in doubt whether these etched specimens should not be regarded as a distinct form. A careful comparison between these individuals and others which have not suffered from weathering shows that they agree in all essential characters and that a separation cannot on present evidence be established. In addition to differences due to preservation, there is some variation in the sculpture of the area and escutcheon which may be noted here. The transverse ornaments of the area are in some individuals more robustly developed than in others; on the escutcheon the linear coalescence of tubercles to form parallel, obliquely running ridges is more complete and regular in some specimens than in others, and the ridges replace the isolated tubercles at an earlier stage of growth. There is also some variation in the arrangement of the tubercles in the lower half of the flank of adult specimens near the frontal margin. The lower terminations of the ribs here tend to turn forwards along the more prominent ridges of growth; some of the tubercles may appear to blend with these ridges, which turn up sharply at the frontal face. Another point in which some variation is shown is in the form of the anterior profile of the shell. In some specimens there is vertical truncation in front, in others the outline of the anterior margin slopes forward somewhat, when traced down from the umbones, so that the foremost point of the shell is situated near to the junction of the inferior and anterior margins.

This is the form referred to by Sharpe as a *Trigonia* allied to *T. herzogi*; he gave the following description of specimens which were presented by J. S. Bowerbank to the Geological Society of London: "*Trigonia* sp.(?). This variety (or possibly distinct species) is closely allied to *Trigonia herzogi*, but is more quadrate in outline than the common variety, the anterior edge being truncate; and the costal rows of knobs turn forward as they approach the ventral border, instead of passing downwards and backwards. These specimens came from Algoa Bay, and apparently have been derived from the Sunday River district, from the aspect of their matrix." \*

*T. holubi* clearly cannot be united with either the *Clavellatæ* or the *Quadratæ*, but its characters are those of the somewhat intermediate kind which led Steinmann to establish the group *Pseudo-*

\* Sharpe (1), p. 202.

quadratae, to receive *Trigonia herzogi* (Goldf.), the well-known Uitenhage form, and *T. transitoria* Steinmann, from Lower Cretaceous strata in Chili, Bolivia, and the Argentine Republic.\* *T. neuquensis* Burckhardt,† which is found associated with *T. transitoria* in the Neocomian *Trigonia*-beds of Las Lajas (Rio Agrio, Argentine Republic), also falls within this division, and another example of the same group is *T. mamillata*, which occurs in the Oomia *Trigonia*-beds near Goonaree in Cutch.‡ These five members of the Pseudo-quadratae show similar deviation from the characters of the two sections with which they may best be compared. Like the Quadratae, they have the escutcheon well ornamented, and the sculpture of the area is in some respects very similar, especially in the manner in which transverse ridges, particularly in the late adult stage, may pass over to the escutcheon on the one hand and the flank on the other. These characters contribute largely to distinguish the group from the Clavellatae, with which, both as regards the youthful ornamentation and the adult form, it has much in common. In the Quadratae the area is usually divided by its longitudinal groove into a broader, superior, and narrower inferior portion; in the Pseudo-quadratae the upper division is the narrower. A row of impressions or pits on the inner valve surface, near the pallial margin towards the posterior end, is present in the Quadratae but absent in the Pseudo-quadratae. In accordance with the position of the longitudinal groove of the area, the lower siphonal channel on the inner valve surface is relatively broad in the Pseudo-quadratae, and may be almost twice as broad as the upper one.

*T. holubi* is most closely comparable with the Indian *T. mamillata*, to which it shows a striking similarity. In *T. holubi*, however, the valve has a rather less convex form, the longitudinal groove of the area is more strongly marked, and the tubercles of the ribs in the early and middle adult stages are much less closely spaced. The most important point of distinction lies in the development of the sculpture of the area. In *T. mamillata* the phase in which irregular transverse costae crossing the area form a dominant feature is reached at a much earlier stage of growth than in *T. holubi*. Thus, in *T. mamillata*, strongly developed costae appear on the area soon after the neanic stage is passed and long before half the adult dimensions are attained. In *T. holubi*, save for the longitudinal groove and its accompanying line of tubercles, the surface of the area is smooth, and only marked by lines of growth, until at least

\* Steinmann (2).

† Burckhardt (2), p. 74, Taf. xiv., figs. 4-6.

‡ Kitchin (1), p. 100, pl. ix., figs. 8, 9; pl. x., figs. 1-3.

half the adult dimensions are attained. The transverse ribs which are subsequently developed on the area are not so well defined or so robust as in *T. mamillata*.

From *Trigonia herzogi* (Goldf.),\* *T. holubi* is readily distinguished by the considerably shorter form, the vertical anterior truncation, the more crowded and much more prominent character of the flank ornaments, and the later appearance of transverse sculpture on the area. In the middle of the flank of an adult specimen, the ribs of *T. herzogi* are straight, while those of *T. holubi* are curved. The backward slope of the posterior flank ribs in *T. herzogi* is another point of distinction.

There is a marked general similarity to *Trigonia transitoria* Steinmann,† from South America, but the ornamentation differs considerably. In *T. transitoria* the tubercles of the costæ on the flank are placed closely against one another through all adult stages instead of being openly spaced as in the ribs of *T. holubi*. In *T. transitoria* also, the development of transverse ridges on the area comes in at a much earlier stage of growth, and, in fact, this ornamentation is a marked character during a large part of the adult life. There appear to be other points of difference which it is unnecessary to enumerate.

*T. neuquensis* Burckhardt is at once readily distinguished from *T. holubi* by its much shorter and higher outline. Here, also, the transverse ridges of the area become a marked feature at an earlier growth-stage than in *T. holubi*. In *T. neuquensis*, the manner in which these ridges in the posterior part of the shell extend downward on to the flank is much more marked than in the most advanced stage in *T. holubi*.

#### *Note on the Development of the Pseudo-quadrate Trigoniæ.*

A strong contrast between the features of the neanic and adult stages may be observed very frequently in species belonging to various sections of this widely conceived genus, but it is seldom that a transition in characters so marked and abrupt as that shown in *T. holubi* is seen to occur during the adult period. The sudden acquirement of strong transverse ridges on the area, a character which is accompanied by a change in the manner of development

\* Goldfuss (1), Band ii., p. 202, Tab. 137, fig. 5 (1837).

† Steinmann (1), p. 260, Taf. iii., fig. 3; Steinmann (2), p. 221, Taf. vii., figs. 3, 4, Taf. viii., figs. 1-3; Burckhardt (1), p. 21, pl. xxv., figs. 1-3; Burckhardt (2), p. 73, Taf. xiv., figs. 1, 2.



of the tubercles of the flank costæ—they become crowded closely together on a given rib—is a very striking feature. In *T. mamillata* from Cutch, these characters are also coincident, but they are acquired at a much earlier period of growth. The members of the Pseudo-quadrata, in the three continents where they are known to occur, seem to have been destined to pass through a similar sequence of developmental phases, but these phases were not reached by all the species at the same time. Thus, *T. mamillata* is in advance of *T. holubi*. In *T. holubi*, the stage where the area is demarcated by an upper and lower marginal row of tubercles and marked by a median longitudinal row, persists until half the adult dimensions have been reached. In *T. mamillata*, this trituberculate stage is passed over rapidly and is superseded in very early adult life. In *T. herzogi* it is superseded by the transversely costate stage (the area alone is still referred to) at a somewhat later period of development, but still not so late as in *T. holubi*. A point of great interest is that in *T. mamillata* and *T. herzogi*, and also in *T. transitoria*, the trituberculate stage may be seen to pass into the transversely costate stage by the progressive transverse elongation of the tubercles in the three sets, and the gradual coalescence of the transverse ridges thus formed. In *T. holubi*, this intermediate phase of development is not so noticeable: it is very much suppressed or is wholly omitted.

The facts here briefly set forth seem to suggest that the group Pseudo-quadrata may be of an artificial character to some extent—that the forms here included for convenience of classification are not strictly homogenetic; and many known parallel instances amongst molluscs and brachiopods give great probability to the truth of this idea. We must suppose all these forms to have been descended from true Clavellata, just as in the case of the Quadrata of Europe, and it is a very striking circumstance that the characters which mark the Pseudo-quadrata should appear approximately at the same geological moment of time in three widely remote continents. Yet these forms are unknown in the European area. The Post-jurassic development shown by the Quadrata and Pseudo-quadrata, each group representing offshoots from one or more clavellate stocks, took place along parallel though independent lines in the European area and in the southern development with which we are dealing. Within each area, again, the development in the supposed several genetic series (which were departing along the same general lines from the ancestral clavellate characters) may be supposed to have been in some degree independent.

Confining our attention to the Pseudo-quadratae, it is difficult to believe that the salient characters by which all the members are distinguished could have been called forth by the ordinary process of natural selection alone. The acquirement of costation on the area coincident in direction with lines of accretion; the encroachment of this simple ornament from the area to the transrescantly sculptured flank in the late adult and senile stages; the prodigal expenditure of shell substance in producing massive sculpture of an increasingly irregular type in these same growth-stages; and the evident variation in many characters which indicates a certain instability of type; all these point to racial degeneracy. A comparison of the Pseudo-quadratae from India, South Africa, and South America, shows that in all of them this degeneracy was expressed as the culmination of a definite sequence of developmental phases. The facts do not warrant the supposition that the members of the group were wholly independent of one another. Their similarity in leading characters was perhaps due, in varying degree, to a number of causes: a certain community of ancestry; continued intercourse until checked by divergence; and at the same time the constant influence of natural selection; all these may have played a part. But it seems difficult to escape from the belief that innate racial tendencies of a very definite kind found their expression in representatives of these *Trigonia*-stocks at the same geological period. Had the members of these genetic series been more passive, so to speak; had they been more plastic and more completely amenable to the call of natural selection, it is scarcely conceivable that environmental conditions should not have occurred at some earlier time which would be capable of producing closely similar results. But the advent of the Quadratae in Europe, and of the comparable though independent Pseudo-quadratae of the south, took place, so far as we know, invariably in Neocomian times.

#### TRIGONIA VAU Sharpe.

Plate VI., figs. 1, 1a, 2, 2a, 2b, 3.

1856. *Trigonia vau* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 194, pl. xxii., fig. 5.

? 1867. *Trigonia vau* R. Tate, Quart. Journ. Geol. Soc., vol. xxiii., pl. vii., fig. 8.

*Occurrence.*—The record of occurrence given by Sharpe was "Sunday River, in greenish-grey grit, with fragments of wood and shells; and in a shelly grit at the Zwartkop River." Speci-

mens preserved in the collection of the Geological Society of London are labelled "Sunday River" (Atherstone and Bain), "Prince Alfred's Rest" (Rubidge), and "Zwartkop River" (Rubidge). Specimens sent to me from the South African Museum are from the Sunday's River. Messrs. Rogers and Schwarz record *T. vau* from the following localities: in the neighbourhood of Uitenhage, ascending the Grass Ridge road, in the uppermost of three beds of sandstone exposed in the dry water-courses, and in the railway cutting between milestones  $24\frac{1}{2}$ – $24\frac{3}{4}$  on the Graaff-Reinet line; on Sunday's River, in the upper beds exposed in a white krantz on Wolve Kraal, on the north bank of the river. In 1905 Mr. Rogers collected specimens 300 yards below Addo Drift (Tunbridge's), left bank of Sunday's River (40h, 41h, 42h). An immature specimen (46h) from the same locality, may also belong to *Trigonia vau*.

*Remarks.*—A large specimen of *T. vau* sent to me from the South African Museum attains a height of 50 mm., measured from the umbo. The ribbing of the flank ceases to be developed at a distance of nearly 10 mm. from the inferior margin, in the neighbourhood of which the shell surface is marked only by ridges and furrows of growth.

Sharpe gave a very accurate and characteristic figure of this remarkable form, but the differences which distinguish *T. vau* from *T. stowi* appear up to the present to have escaped observation, and it is probable that the shells cited under the name *T. vau* by Stow\* are in reality to be ascribed to *T. stowi* sp. nov. I have had the opportunity of examining and comparing a considerable number of excellently preserved specimens of these two *Trigoniæ*, and find that the characters which distinguish them from one another are very constant. Several fully-grown shells of *T. vau* sent to me from South Africa agree very perfectly with the original type and other individuals in the collection of the Geological Society. The points of distinction which may be readily observed in the adult shells of *T. vau* and *T. stowi* are set forth in the remarks which follow the description of the latter. During the youthful growth-stage, however, these two forms cannot be separated, so that it is uncertain to which must be ascribed a young specimen obtained by Messrs. Rogers and Schwarz at Walton's Farm, just below Dunbrodie on the Sunday's River (307), and another individual measuring 17 mm. in length, collected between milestones  $24\frac{1}{2}$ – $24\frac{3}{4}$  on the Graaff-Reinet railway (309). There is the same doubt concerning an immature

\* Stow (1), pp. 499–505.



specimen from Addo Drift (46h). For the same reason it is uncertain whether the young individual figured by Tate really represents the true *T. vanu*. Tate's figure, which represents the specimen in twice the natural size, unfortunately does not give a very satisfactory picture of the youthful characters of either of these shells.

The close agreement in the characters of the neanic stage reveals the near relationship of these two forms, and, indeed, such a relationship might reasonably be inferred from a comparison of adult characters, which coincide in a remarkable manner as regards the ribbing of the flank and the posterior elongation. Other shells, however, which when adult exhibit similar peculiarities of form and ornamentation, differ widely from *T. vanu* and its associate when in the youthful stage. These are the members of the *Trigonia v-scripta* group in the marine Oomia beds of Cutch,\* and a comparison of their youthful characters and those of *T. vanu* and *T. stowi* is given in the remarks which are appended to the description of the latter. *T. stowi* when adult approaches closely in many particulars to *T. v-scripta* itself, but the adult *T. vanu* agrees much more closely with *T. dubia* Kitchin, so far as the unsatisfactorily preserved Indian specimens allow of comparison. In consequence of imperfect preservation, the nature of the sculpture in the youthful stage of *T. dubia* is not known, but it appears reasonable to assume that it bears closer relationship to the other members of the group of *T. v-scripta* than to *T. vanu*. In the adult stages, too, points of distinction between *T. dubia* and *T. vanu* are not wanting. These have been set forth in my account of the characters of *T. dubia*† as follows: "In *T. vanu*, the ribs of the anterior series, though narrow and crowded as in *T. dubia*, are seen to be upwardly inclined as they depart from their point of meeting with the posterior series, and are crossed obliquely by the lines of growth. In *T. dubia*, on the other hand, these anterior costæ are placed in a direction quite, or almost, parallel to the inferior border, and the angle of the lateral V is therefore not so acute. Moreover, before individuals of *T. vanu* have reached half their full dimensions, the costæ of the frontal series cease to be formed close to the frontal border. There arises, therefore, a space devoid of ornamenting ribs, marked only by ridges and furrows of growth, and bounded posteriorly by the last-formed obliquely directed costæ of the frontal series. This peculiar character is totally absent in *T. dubia*, in no specimen of which is a frontal unsculptured space seen, although in respect to size

\* Kitchin (1), p. 65.

† Ibid., p. 69.

all the individuals examined considerably exceed the dimensions at which this feature becomes noticeable in *T. vau*. . . . Sharpe's type is of larger dimensions than the known specimens of *T. dubia*."

The extent to which an unsculptured space near the lower part of the frontal margin may be present in *T. vau* is really somewhat variable, but a few of the lowest ribs of the anterior series seem always to fail to extend at their upper terminations to the valve margin. In some individuals, two or three of these lower ribs may be slightly bent down at their anterior ends in manner reminiscent of the strong, angular bending at the front end of these ribs in *T. stowi*, as well as in the Indian *T. v-scripta*. It may also be noted that although the inclination of the frontal series of costæ in *T. vau* is always as steep as in the specimen depicted in Sharpe's figure, yet these ribs may in some instances attain a stronger development and may be of a rather more robust character.

A shell possibly related to *T. vau* is *T. kühni* G. Müller,\* from Neocomian strata at a locality 23 km. west-south-west of Mtshinga in German East Africa. To judge from the description and figures, this is distinguished by an angular rib arrangement very similar to that exhibited by the members of the group of *T. v-scripta* in India, and *T. vau* and *T. stowi* in South Africa. *T. kühni* seems to differ, however, by its less equilateral form and the persistent ornamentation of its area. The figure of an imperfect specimen of *T. kühni* (fig. 8) shows a curved frontal profile and the ribs of the frontal series obliquely crossing the growth-lines in manner that recalls the same characters in *T. vau*, though still more reminiscent of *T. recurva* Kitchin, from the Oomia beds. It is as yet not possible to say, however, whether *T. kühni* is more nearly related to *T. vau* or to the group of *T. v-scripta*, though it may be anticipated that a study of the youthful characters will ultimately throw light on this point.

*Trigonia heterosculpta* Stanton,† from the Belgrano beds (Lower Cretaceous) of Patagonia, is very probably closely related to *T. vau*, but differs by the much shorter and more elevated triangular figure. The first-formed ribs of the posterior series are vertical or backwardly inclined, and not forwardly sloped as in *T. vau*, while several successive anterior ribs terminate abruptly on the flank of a single vertical posterior rib. In the neanic stage, however, the plan of sculpture as well as the form of the valve appears to agree closely with that of *T. vau*.

\* G. Müller (1), p. 561, Taf. xxv., figs. 6-8.

† Stanton (3), p. 20, pl. iv., figs. 16-18.

R. A. Philippi\* has figured some Chilian forms (for example, *T. arsinoe* Philippi, *T. foveata* Philippi) which may be related to *T. vau*; they are characterised by great posterior elongation, very convex anterior profile, and two series of ribs on the flank meeting at an angle. The general aspect, indeed, at once suggests the probability of relationship with the two South African types, but the Chilian shells are so unsatisfactorily figured, and their preservation appears to have been so imperfect that further and critical comparison is not possible.

Whiteaves has drawn attention to the features wherein *Trigonia diversicostata* Whiteaves,† from the Cretaceous of Queen Charlotte Islands, bears resemblance to *T. vau*. These are: the elongated and posteriorly strongly produced figure of the shell, the convex anterior profile and recurved umbonal region, and the general plan of sculpture on the flank. In *T. diversicostata*, however, the anterior ribs are much coarser in character than in *T. vau*, and are directed almost parallel to the lower valve margin, thus forming a right angle with the posterior ribs instead of an acute angle. A good distinctive feature is seen in the area of the Canadian shell, which is coarsely ornamented by strong longitudinal ribs, and this alone is sufficient to indicate that the two forms are in no way nearly related, but that the common characters of shape and broad plan of flank sculpture have been quite independently attained. Whiteaves ascribes *T. diversicostata* to the section Scaphoideæ, but all members of this division bear evidence of a clavellate ancestry, and longitudinal ornamenting ridges on the area are unknown amongst them. Such ornaments are essentially characteristic of the Costatæ, from which *T. diversicostata* was quite probably derived, and rapid divergence from the typical pattern of the section might well result in this aberrant form, in manner analogous to that exhibited in some of the modified Costatæ of the marine Oomia beds in Cutch. *T. vau* shows no signs of a connection with the section Costatæ at any early growth-stage that can be studied, but the ornaments of the area are transverse from the first.

The peculiarly ornamented *Trigonia doroschini* Eichwald,‡ from the Neocomian of Tukusitnu Bay (Alaska), may finally be brought into comparison. This appears to me, however, to be well separated from the group of *T. vau* (as well as from the group of *T. v-scripta* in India) by the more truncated and less convex anterior margin and by the manner in which the frontal ribs are directed at right angles

\* R. A. Philippi (1), pls. 34, 35.

† Whiteaves (1), p. 68, pl. x., fig. 1.

‡ Eichwald (2), p. 180, pl. xiii., figs 12-14; xiv., figs. 1-4.



to the frontal margin. It seems doubtful from Eichwald's figures whether a single form alone is represented, for it is difficult to believe that the originals of pl. xiii., fig. 12, pl. xiv., fig. 1, and pl. xiv., fig. 3 can belong to one species. Other points in which these differ from *T. vau* are the great extent of the frontal ribs, the horizontal position of these, and the persistent transverse ornaments on the area. Eichwald's description and figures leave the affinities of *T. doroschini* obscure, but I think it improbable that it is related to the group of *T. vau*.

TRIGONIA STOWI sp. nov.

Plate VI., figs. 4, 4a, 4b, 5; VII., fig. 1.

*Description.*—The shell is of very elongated form, moderately inflated, anteriorly pointed, posteriorly very much produced, and slightly gaping at the siphonal margin. The umbones are situated at some point lying between one-quarter and one-third of the shell's total length from the anterior extremity; they are well incurved and slightly recurved. The umbonal region is fairly prominent and inflated. Posteriorly to the umbo, the very long cardinal margin forms a straight or very gently concave outline and passes posteriorly by a curve into the short, convex siphonal margin. Anteriorly to the umbo, the valve margin slopes downwards with straight profile to the projecting anterior extremity, where it forms a sub-angular or sharply curved junction with the lower margin; the latter forms a gentle and evenly convex profile as it is traced between the anterior and posterior extremities of the shell.

At no stage of growth is a marginal carina developed; in the youthful stage its place is represented by a blunt carinal fold which passes with advancing growth into a still broader and less well defined rounded fold of the valve. At the siphonal end of an adult individual this loses definition and the valve becomes evenly convex.

In the youthful shell, until the valve attains a height of about 8 mm. measured from the umbonal apex, the ornamentation consists of numerous, crowded linear ribs which are parallel to the lower margin and extend from the frontal border across the flank; they pass over the carinal angle and across the area. Up to a distance of between 5 mm. and 10 mm. from the umbonal apex these ribs extend across the escutcheon also, and terminate either at the cardinal margin or just before reaching it. Subsequently they cross the area though not the escutcheon, until a distance of about 10 or 12 mm. from the umbonal apex is reached, after which they occupy the flank only, terminating at the carinal angle, while the area subse-

quently remains smooth. In the space between 10 mm. and 20 mm. from the umbonal apex, the very blunt ridge demarcating the area from the escutcheon is ornamented by minute, transversely elongated nodes or short raised lines, each measuring about one millimetre in length. At a distance of about 10 mm. below the umbo the ribs on the flank become bent down in the middle in angular form and become more widely spaced. The transition from the straight to the angularly bent flank-ribs is somewhat sudden. Three or four bent ribs are successively produced, having a more delicate anterior and more robust posterior limb, and an increasing acuteness of the angle. Subsequently, an anterior and a posterior series of inclined ribs may be spoken of, not strictly coinciding with each other in number. The anterior ribs, numbering about 14-16 in the adult, often cease to extend to the frontal margin after the shell has attained half its adult dimensions; their upper, anterior terminations are situated on the flank at an increasing distance from the margin, and forming acute angles with these, with upwardly directed apices, are several short, steeply inclined, weak and rather broader ribs. Each of these is only a few millimetres in length and might be considered to represent the downwardly bent anterior termination of a rib of the anterior series. The most forward portion of the flank is usually devoid of sculpture and marked only by ridges and furrows of accretion. The lowest ribs of the anterior series become in varying degree irregularly nodose or broken into wavy lines of nodes with loss of regularity near the lower valve margin. The ribs of the posterior series have their upper termination at first close to the carinal fold, and successively at a gradually increasing distance from this, so that a narrow portion of the flank adjacent to the fold is smooth. These ribs are not developed to the posterior end of the flank in the adult, but there is here a smooth tract only marked by lines of growth. The ribs of the posterior series, developed to the number of about 14, are very steeply inclined, and all have a slight forward slope. They are of rounded form, are about 3 mm. in breadth, and have slightly narrower interspaces.

The area is relatively narrow, and is marked throughout the adult period by a longitudinal linear depression. In the posterior half of the area this marks off a narrow superior and broader inferior portion. There is no defined inner carina, and the line of delicate and imperfectly developed nodes which marks the inner limit of the area at a distance of 10-20 mm. from the umbonal apex is a transitory feature, and does not persist with subsequent growth. The escutcheon is relatively very long and is of lanceolate form, and

though imperfectly demarcated from the area, it is marked by its excavated form and smooth surface. Ridges of growth which cross the area are replaced by very delicate and scarcely perceptible lines of accretion on the escutcheon. At a distance of 15 mm. from the umbones the escutcheon in each valve is fully as broad as the area. The ligament pit is relatively short and broad.

<i>Dimensions.</i> —	(1)	(2)	(3)
Greatest length.....	80	95	110 mm.
Height, measured from the umbo	42	44	50 „
Greatest depth of a single valve ...	14	15	20 „

*Occurrence.*—Marine Beds of Sunday's and Zwartkop's Rivers. Specimens in the collection of the Geological Society of London are labelled "Zwartkop River" (Rubidge); "McLoughlin's, bed No. 5" (Stow); "Above Modder Drift, No. 3 bed" (Stow).\* In the British Museum (Natural History) a fine specimen is labelled "Sundays River, Pont." A specimen sent to me from the South African Museum is believed to come from the Sunday's River cliffs. An immature specimen, 15 mm. in length, and a portion of the flank of an adult in the form of an external mould, resembling *T. stowi*, were collected by Messrs. Rogers and Schwarz at Walton's Farm on the Sunday's River, just below Dunbrodie (307). These may probably represent *T. stowi*, though they might equally well be ascribed to *T. vau* so far as their characters allow of determination. Another immature specimen, from the railway cutting between milestones 24½–24¾ on the Uitenhage–Graaff-Reinet railway (309) may also perhaps belong to this form. Mr. Rogers collected *T. stowi* in a small kloof, three miles up the left bank of Sunday's River (17h). A hand-specimen containing one complete and two fragmentary valves was also obtained by him from a cliff W. 20 S. from Comley's house, right bank of Sunday's River (90h).

*Remarks.*—This form shows some variation in regard to the shape of the frontal profile and the position of the umbones in relation to the anterior extremity. In some examples, the anterior sculpture is more robust and more regular than in others. The thickened and downwardly directed terminations of the anterior ribs are sometimes a very prominent feature, in other cases they are less noticeable. In some individuals the anterior ribs are very closely spaced, and towards the lower part of the adult valve may be much broken up into nodes (as exemplified by specimen 17h). Sometimes a small portion of the flank, most anteriorly situated, is

\* See Stow's table of cliff-exposures at localities on "Upper Sundays River" and "Lower Sundays River"; Stow (1), fig. 3.



smooth, in other cases the ribbing extends to the frontal margin at all parts. Near the pallial margin of large individuals senile characters may be seen in the cessation of sculpture and the appearance of several strong furrows of accretion.

Two right valves in the specimen numbered 90h have a more rounded and less sharply pointed anterior profile than any of the other specimens studied. They also have the umbones rather more anteriorly placed. The other extreme, illustrating the less inequilateral form of the valves and the more marked pointing of the anterior profile, is shown by an individual from the collection of the South African Museum. Characters quite intermediate between these extremes are exhibited, for example, by a specimen numbered 12006 in the collection of the Geological Society of London. I believe, therefore, that the material examined only suffices for the establishment of a single species.

Stow appears to have believed this form to represent *T. vau* Sharpe. When dealing with the *Trigoniæ* of the Oomia beds of Cutch, I made reference to *T. stowi* as an undescribed form allied to *T. vau*.<sup>\*</sup> In addition to the specimens there referred to, I have since had the opportunity of examining further material in the collections of the Geological Society and the British Museum (Natural History), and also the fine specimens sent to me from South Africa. *T. stowi* is a very well characterised form, peculiar for its elongated outline, its pointed anterior extremity and greatly produced posterior region, its striking flank-sculpture and its siphonal gape. Although in many points, and particularly in the sculpture of the adult, it very strongly recalls the Oomia *T. v-scripta* Kitchin, yet its youthful characters plainly reveal its close relationship to *T. vau* Sharpe (see above). Until the young shell has attained a height of about 10 mm., these two African forms are so alike that I have been unable to find any feature by which they may with certainty be distinguished. In the adult stage, however, *T. stowi* has a more elongated outline and is more strongly produced posteriorly; its umbones are relatively further removed from the anterior extremity; the upper and lower valve-margins converge towards the front to join in more or less pointed form, and produce a frontal profile which stands in contrast to the sweeping convex outline of the frontal margin in *T. vau*. The angularly bent and swollen anterior portions of the ribs in the frontal series, which produce such a peculiar pattern in the sculpture of the anterior quarter of the flank in *T. stowi*, are developed to a much

<sup>\*</sup> Kitchin (1), pp. 66, 74.

less noticeable extent in *T. vau*, and the bending is absent in some individuals.

When studied in connection with the shells of the group of *Trigonia v-scripta* from the Oomia beds of Cutch, *T. stowi* can only be closely compared with *T. v-scripta* itself. Though, when adult, it resembles this in most striking manner in the backward position of the umbones, the posterior elongation and general form, and especially in the character of the flank ornamentation, *T. stowi* may be readily distinguished by its relatively more elongated and posteriorly attenuated figure, and its anteriorly more acutely converging upper and lower margins. *T. v-scripta* is a shorter shell relatively to height, particularly in the late adult and fully grown state, while its valves are somewhat flatter and less inflated. In the youthful stage the two are widely different in character; *T. v-scripta* then has a very few coarse concentric flank-ribs, which, continuing across the well-marked carinal angle, pass obliquely forwards over the area in the form of attenuated thread-like raised lines, and terminate at a delicate linear ridge which represents an inner carina. Similar characters distinguish the young *T. recurva*, another Oomia form. This, like *T. stowi*, has strong posterior elongation in the adult, and a smooth tract on the posterior portion of the flank; but it is well contrasted by its much smaller size, its rounded convex frontal profile, its more crowded and much less steeply sloped anterior ribs, and its imperfectly developed, short posterior ribs.

*T. heterosculpta* Stanton,\* from the Belgrano beds (Lower Cretaceous) of Patagonia, is very probably a related form. Its youthful characters are closely similar to those of *T. stowi*, but the adult shell is much shorter, more triangular in form, and much less elongated posteriorly, while there are marked differences in the details of sculpture.

#### TRIGONIA CONOCARDIIFORMIS (Krauss).

Plate VII., figs. 2, 2a, 2b, 3, 4.

1843. *Lyriodon conocardiiformis* F. Krauss, Amtlicher Bericht über die zwanzigste Versammlung der Gesellsch. deutsch. Naturforscher und Aerzte zu Mainz im Sept., 1842, p. 130.

1850. *Lyriodon conocardiiformis* F. Krauss, Nov. Act. Acad. Cæs. Leop.-Carol. Nat. Cur., vol. xxii., pt. 2, p. 454, Tab. 49, figs. 1a-1d.

\* Stanton (3), p. 20, pl. iv., figs. 16-18.

1879. *Trigonia conocardiiformis* J. Lycett, Mon. Brit. Foss. Trigoniæ, pp. 210, 211, and woodcuts; p. 230. (Palæontographical Society.)

1903. *Trigonia conocardiiformis* C. Burckhardt, Beiträge zur Kenntniss der Jura- und Kreideformation der Cordillere. Palæontographica, Band 1., Taf. xiii., figs. 3-5.

*Supplementary Descriptive Note.*—Krauss gave an admirable detailed description of this very characteristic shell, but I am able to supplement this by some additional observations, based on the examination of material more favourably preserved than that which appears to have been at his disposal. There are one or two points, also, in which the figures accompanying Krauss's description are rather misleading.

With regard to the ribbing of the flank, it must be noted that this does not always strictly conform with the simple plan illustrated in the figures given by Krauss and Lycett. It may be remarked that if the figures of the German author are imperfect, that given by Lycett to illustrate the exterior of a left valve is still less characteristic, although it was intended to supply the deficiencies of the earlier illustrations.

Several specimens now examined are in such condition as to show the form of the sculpture in early growth-stages, and two individuals, in particular, have the ornaments of the nepionic and neanic stages well preserved. One is an imperfect left valve which measures 9 mm. in length, and would be 7 mm. in height if uninjured at the pallial border; it occurred in a hand-specimen, containing adult *T. conocardiiformis*, *T. vau*, and other typical forms, from the Sunday's River. The other specimen is an immature individual having both valves in place, imperfect posteriorly, but beautifully preserved in the umbonal region. This was collected by Mr. Rogers from a cliff on the right bank of Sunday's River on Commando Kraal (104h). Other specimens, also, show the ribbing of the neanic stage, though less perfectly. It is seen that until the valve attained a height of about 6 mm., measured from the umbonal apex, the flank was ornamented by simple concentric ribs, running parallel to the lower margin. Close to the apex the crests of the ribs are situated at a distance of about 0.5 mm. apart; at about 5 mm. below the apex the distance between the ribs has increased to 1 mm. These concentric ribs extend to the frontal margin. Traced backwards, they pass over the flank to a definite carinal ridge, and becoming more delicate in character, turn sharply forwards and pass across the relatively narrow area. There is no inner carina



even at this early stage, but the ribs encroach slightly upon the smooth escutcheon. This is clearly seen in the neanic stage, where the escutcheon begins to increase rapidly in breadth. Very close to the umbonal apex, however, it is difficult to observe traces of an escutcheon, and here the attenuated and delicate linear ribs of the area pass obliquely forward until almost reaching the cardinal margin, when they die out. Where they disappear, very close to the cardinal border, the ribs are extremely attenuated and crowded, while directed to form an acute angle with the valve-border. The longitudinal linear groove of the area which becomes so marked a feature in the adult, is only faintly indicated at the close of the neanic stage.

As the succeeding growth-stage is entered upon—that is, when the valve exceeds 8 mm. in height—the carinal angle rapidly becomes rounded and blunt, and soon takes the form of a broad fold. The ribs of the flank are now prominent and robust, and are separated by interspaces 3 mm. broad. They pass obliquely downwards when traced forwards. There is some variation shown in the relation of the anterior ribs to the succeeding posterior ones in the adult stage. Sometimes the first four or five strong ribs have their posterior terminations on the flank at successively greater distances from the carinal fold. Immediately behind these, and forming a separate series having an almost vertical arrangement, are the numerous and much more delicate ribs of the posterior series. They have their superior terminations immediately below the carinal fold. The sixth or seventh rib of the anterior series is in continuity with the second or third rib of the posterior series, forming the lower and more strongly developed portion of it, this lower portion being directed to form a very obtuse angle with the upper portion. Posteriorly to this, the ribs are not divisible into two series. In other specimens, however, the successively formed ribs have their upper terminations alike close under the carinal fold of the valve, and there is no tendency to division of the ribs into two series. There is also considerable variation in the strength and number of the ribs. In some specimens the ribs are more strongly developed and are rather less numerous than in other individuals of equal size; sometimes their more strongly swollen character may be particularly noticeable on the posterior half of the flank.

The area throughout the adult stage is devoid of ornamentation except the well-marked longitudinal groove. The escutcheon is of very elongated lanceolate form. It is not separated from the area by any definite carinal ridge, but is well marked off for the most

part by being sunk in concave form. Towards the posterior end it is scarcely demarcated.

*Dimensions.*—*Trigonia conocardiiformis* may attain very large dimensions. A specimen presented by Átherstone to the Geological Society of London has a maximum length of 164 mm. This specimen, which is not quite complete at the lower margin under the umbonal region, must originally have had a height (measured at this part) of 95 mm. The ligament groove is 45 mm. long. A specimen figured by Krauss is 84 mm. in length and 42 mm. in height (at the umbonal region), while the depth of a single valve, measured from the figure, is 24 mm. In several individuals examined by me, the height is somewhat greater than this, in relation to the length.

*Occurrence.*—This form is found in the Marine Beds at various localities on the Sunday's and Zwartkop's Rivers. It was obtained by Messrs. Rogers and Schwarz from the railway cutting between milestones  $24\frac{1}{2}$ – $24\frac{3}{4}$  on the line from Uitenhage to Graaff-Reinet (297, 298); also at the white krantz on Wolve Kraal on the north bank of Sunday's River. The same authors have mentioned the occurrence of this shell in a conglomeratic bed at Plettenberg's Bay.\* Specimens in the collection of the South African Museum are from the Sunday's River. In 1905, Mr. Rogers obtained examples in the cliff on Commando Kraal, right bank of Sunday's River (104h); in the highest beds on Zoet Geneugd, right bank of Sunday's River (67h); on a bare slope W. 30 S. from the middle of Barkly Bridge, on the farm Olifant's Kop, Sunday's River (21h); and from the Nek S. 33 E. from Comley's house, right bank of Sunday's River (86h).

*Remarks.*—A very striking feature exhibited by this *Trigonia* is the sudden transition of sculptural characters at the close of the neanic stage. The abrupt manner in which the crowded concentric ribs give place to coarse, widely spaced, inclined ribs, recalls the analogous transition in *Trigonia vau* and *T. stowi*; in these, the youthful stage has similar though more delicate concentric ornaments, and these are replaced almost as abruptly by angularly bent, coarse ribs. The youthful characters of *T. conocardiiformis* seem perhaps to suggest an ancestry similar to that from which *T. vau* and its ally were derived. In the young *T. conocardiiformis*, however, the carinal ridge is more clearly defined, and in passing across this the ribs are sharply bent to form an angle. The early characters do not seem to indicate alliance with either the Scabræ

\* Schwarz (1), pp. 53, 61; Rogers and Schwarz (1), p. 5; Rogers (1), p. 295.

or the Costatæ; but in view of the remarkable manner in which widely divergent types of *Trigonia* in the Oomia beds of Cutch show, by their neanic characters, their relationship to the Costatæ, it would not have been surprising to obtain evidence of a similar descent in *T. conocardiiformis*. The young stages, however, exhibit no trace of longitudinal ornamentation on the area, and it is difficult to surmise its true derivation.

*T. conocardiiformis*, by reason of its peculiar characters of outline and sculpture, has for long held a somewhat isolated position among the representatives of the genus. Lycett at first expressed the belief that it is an abnormal example of the Clavellatæ, only remotely related to other members of the section;\* but he afterwards modified his opinion and associated this form with the "crenulated examples of the Scabræ."† Definite indications of such a relationship, as we have seen, are not to be recognised.

It is a point of great interest that on the South American continent, an apparently very close ally of *T. conocardiiformis* has been found to occur, and in association with two members of the Pseudo-quadratæ. The shells described by Burckhardt‡ under the name "*Trigonia* aff. *conocardiiformis*" were collected from strata ascribed to the Lower Neocomian at Las Lajas (Argentine), and they certainly bear a very remarkable resemblance to this South African form. In general figure and outline the similarity is very striking, while differences in the hinge apparatus of the left valve are of a minor character. The principal points of distinction are in the nature of the sculpture of the flank in the adult stage; regarding the sculptural plan in the youthful stage of the South American shell, no information is as yet forthcoming. The tendency in some few individuals of *T. conocardiiformis* to show a development of two distinct series of ribs on the flank during the early adult stage is illustrated in more complete and emphasised manner during the whole adult period in the South American shell. Most of its anterior ribs, though in continuity with ribs of the posterior or vertical series, form an obtuse angle with these, and pass across the flank towards the frontal border in a direction more nearly horizontal than the downwardly directed anterior portions of the ribs in *T. conocardiiformis*. The contrasted aspect of the sculpture in the two forms is well illustrated in plate xiii. of Dr. Burckhardt's monograph, where figures of African and South American individuals are presented side by side.

\* Lycett (3), p. 121 (1875).

† Ibid., p. 210 (1879).

‡ Burckhardt (2), p. 72, pl. xiii., figs. 1, 2.



Another South American form which is probably also nearly related, is *Trigonia eximia* R. A. Philippi,\* from the Tinguirica valley in Chili. This represents a type of shell very closely comparable with *T. conocardiiformis*, but the complete differentiation of the ribs into a posterior and an anterior series is a marked feature of the adult stage. With regard to this character of the ribbing, the form described by Burckhardt under the name *Trigonia* aff. *conocardiiformis* may be regarded as illustrating a somewhat intermediate type of sculpture between the two extremes, *T. conocardiiformis* and *T. eximia*. Another probably allied shell has been recorded by Haupt† from the Neocomian of Loteno, on the Rio Neuquen, on the east slope of the Argentine Cordillera, under the name *Trigonia* cf. *eximia* Philippi. This is said to differ from Philippi's type chiefly in having the dividing line between the anterior and posterior ribbing more obliquely directed. *T. eximia* is referred by Haupt to the section *Undulatæ*, but this is an obvious error. These aberrant forms in South Africa and South America have in common certain peculiar characters of shape and ornamentation by which they differ in marked manner from all divisions of the genus known to occur in the Jurassic rocks. It is not improbable that we are here dealing with representatives of several parallel series developed from some common ancestral species or group of species, showing rapid departure from the ancestral type along similar lines of development, the successive phases being attained, however, at an unequal rate. On the other hand, the possibility that convergence is illustrated is not remote. In the above description of *T. conocardiiformis*, differences observable in the plan of sculpture after the close of the neanic stage are ascribed to individual variation. I believe this to be sufficient to account for such differences, but the possibility is not excluded that in the Uitenhage beds, two very closely similar forms, undergoing parallel development, are present. It may be that those individuals which show some division of the ribbing into two distinct sets forming an angle with one another, at the beginning of the adult stage, illustrate a series which has passed through a stage similar to that represented in the adult *T. eximia*, and that this stage, with angularly disposed costate ornamentation, has become suppressed by tachygenesis and reduction. The entire absence of characters of sculpture which approach those of *T. eximia*, in the other individuals from Cape Colony, might probably be due to the same cause.

\* R. A. Philippi (1), p. 76, pl. xxxiv., fig. 3.

† Haupt (1), p. 216.

## TRIGONIA TATEI Neumayr.

1867. *Trigonia cassiope* R. Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 158.

1881. *Trigonia tatei* M. Neumayr, in E. Holub and M. Neumayr, Denkschr. d. k. Akad. Wiss., Math.-Nat. Cl., Band xlv., p. 275, pl. ii., fig. 3.

*Occurrence*.—A very imperfect and ill-preserved fragment of a costate *Trigonia* occurs in hard limestone with *Pleuromya bairdi* from Grass Ridge, three miles east-north-east of Uitenhage (335). In all probability this represents *T. tatei*.

*Remarks*.—Although no complete or satisfactorily determinable specimens of this well-characterised form are included in the collection under examination, it may be useful to draw attention to one or two points of interest in reference to the occurrence of this shell, the only member of the section Costatæ hitherto found in the Uitenhage beds. In 1877, Lycett\* cast doubt upon the correctness of Tate's identification of this South African form with the European Oolitic shells named *T. cassiope* by d'Orbigny,† and Neumayr subsequently saw the necessity of applying a new name. *T. tatei* certainly cannot be united with any other known costate form, and although the general outline and nature of the ribbed flank has a close parallel in several familiar European Costatæ, yet the narrow area and elongated escutcheon, the delicate and little-prominent carinæ and inter-carinal ridges, and the relatively very delicate beaded ornamentation of area and escutcheon, are very distinctive features.

Two specimens preserved in the collection of the Geological Society of London are labelled "Zwartkop River" (H. Longlands) and "McLoughlin's Rest" (Major Rocke) respectively, and the former specimen appears to have been the one upon which Tate's identification was based. The length is relatively great compared with the height; the cardinal margin is elongated, while the siphonal margin is short. The area is slightly convex in form, without a marked median carina or groove; the escutcheon is large, and ornamented by raised lines of granules running parallel to the ridges of the area. There are about 18 ribs on the flank of the larger specimen. The elongated form, the very delicate carinæ, the fine intercarinal sculpture, the convex area, and the elongated granular escutcheon, are all characters which at once recall the

\* Lycett (3), p. 172.

† d'Orbigny (4), vol i., p. 303.

same features in *T. tenuis*, from the Oomia beds in Cutch.\* This, however, is strongly distinguished from *T. tatei* by the very crowded and delicate costate ornamentation of the flank, and by the slight convexity of the valve.

In view of the comparative rarity of the Costatæ in the Cretaceous rocks, the occurrence of so typical a member of the section in the Uitenhage Series might appear at first sight to lend some support to the view of those who have maintained that a part, at least, of these beds must be ascribed to the Upper Jurassic. It is clear, however, that in any attempt to uphold such a conclusion, less weight can now be attached to the presence of Costatæ than when our knowledge of the distribution of this division of the *Trigonia* was founded principally upon European occurrences. In Europe itself, representatives of the section are sparsely present in the Cretaceous, and these mostly show deviations which at once distinguish them from the typical Jurassic forms. *Trigonia peninsularis* Coquand,† from the Aptian of Spain, exhibits a marked degeneration of characters in its later growth-stages, while *T. carinata* Agassiz,‡ from the Neocomian and Aptian, which may be brought into the most intimate connection with the Costatæ, shows equally far-reaching modifications, although an examination of Lycett's figured specimens and other well-preserved individuals fails to reveal any characters which can be taken to justify Lycett's separation of this form under a separate sectional heading.§ The typical features of the section Costatæ are exemplified, however, in a small *Trigonia* described by E. Ascher from the Hauterivian of Silesia.||

Although these European forms may be looked upon as lingering representatives of a section which had passed its maximum development, we must look further afield in order to complete the history of this strongly characterised and long-lived division of the genus. In the marine Oomia beds of Cutch, which may now be regarded as of Lower Cretaceous rather than of Upper Jurassic age, aberrant derivatives of the Costatæ provide a striking feature in the molluscan fauna; but here also have been found two representatives, *T. tenuis* Kitchin and *T. parva* Kitchin, which retain in perfect manner the typical characters of the section. South America has also furnished another unmodified Cretaceous costate form in *T. anguste-costata*, described by Behrendsen¶ from strata which he regards as Upper

\* Kitchin (1), p. 35, pl. iii., figs. 5, 6. † Coquand (1), p. 129, pl. xxiii., fig. 3.

‡ Agassiz (1), p. 43, Tab. vii., figs. 7-10; Lycett (3), p. 179, pl. xxxv., figs 3-6, (1877).

§ See also Collot(1).

|| Ascher (1), p. 159 [25], pl. xiii. [ii.], fig. 10. ¶ Behrendsen (1), p. 6, pl. 3, fig. 7.



Cretaceous, at Caryilauhue (Argentine); this is accompanied by a typical member of the Cretaceous section Scabræ, *T. transatlantica* Behr. *T. anguste-costata* is a small triangular shell, which in the delicate character and close spacing of the flank-ribs recalls the Indian *T. parva* Kitchin, from which, however, it is widely distinguished by the very different outline and the delicate ornamentation of the area. In the perfect development of these longitudinal ridges of the area, *T. anguste-costata* retains in typical manner an essential feature of the section, a differentiation of the valve-sculpture which so strongly and constantly characterises all the Costatæ. With reference to the occurrence of the costate *Trigonæ* in Cretaceous rocks, Behrendsen cites, in addition to *T. peninsularis* Coquand and *T. carinata* Agass., the following shells: *T. longa* Ag., *T. pennata* Sow., *T. cardissa* Ag., and *T. indica* Stoliczka. This list, however, is misleading, as may be ascertained from a careful examination of these forms. *T. longa* and *T. pennata* certainly cannot be included in the section Costatæ, while it is doubtful whether *T. indica* stands in very close connection with this division. *T. cardissa*, on the other hand, is a typical representative of the section, but it has been shown to be Jurassic,\* and not Cretaceous, as at first suggested on insufficient grounds by Agassiz.

#### GENUS CARDITA J. G. Bruguière.

##### CARDITA NUCULOIDES Tate.

Plate VII., figs. 5, 5a, 5b.

1867. *Cardita nuculoides* R. Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 162, pl. vii., figs. 7a-7d.

*Occurrence*.—Tate's figured specimen, numbered 11028 in the collection of the Geological Society, came from the Sunday's River. A specimen obtained by Mr. Rogers is from the left side of the Coega Valley, half a mile down from the railway (466g).

*Remarks*.—The specimen found by Mr. Rogers is a well-preserved left valve which differs slightly in outline from Tate's figured type: it is a little more drawn out obliquely, and the convex fold of the valve which runs obliquely from the umbonal region to the postero-ventral corner is rather more pronounced than in the original type. Tate's specimen, however, although having both valves in place, is not so perfectly preserved, and some allowance may also be made for individual variation. The general form of the shell,

\* Bigot (1), p. 292.

and the complete agreement in the sculpture, leave no doubt that the specimen from Coega Valley must be identified with *C. nuculoides*.

The form of the shell is that of a four-sided figure with rounded angles. The anterior margin is short, the posterior margin, on the other hand, very extensive. The umbonal region is relatively weakly developed. The surface is beautifully ornamented by numerous, minute, radial striæ which cannot be seen with the naked eye. The intercrossing of the striæ with concentric growth-lines results in a delicate cancellation.

#### GENUS ASTARTE J. Sowerby.

##### ASTARTE LONGLANDSIANA Tate.

1867. *Astarte longlandsiana* R. Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 158, pl. viii., figs. 5a, 5b.

*Occurrence*.—Specimens in the collection of the Geological Society are from the Zwartkop's River. Mr. Rogers obtained an immature example of this form in the Coega Valley east of the railway, one mile up the line from Coega station (477g).

*Remarks*.—The immature specimen from the Coega Valley measures only 19 mm. in height. It has both valves in position, and the umbonal region of the right valve is perfectly preserved. The umbo is acutely pointed and is ornamented by closely spaced concentric ribs up to the apex. Tate says that the valves are ornamented with "slightly elevated ridges of growth," but it would be more correct to say that the ornamentation consists of well-raised concentric ribs. The ribs show some little irregularity of spacing. The surface between the rib-summits frequently shows finer concentric lines, which appear here and there to have the regularity of definite sculpture, though in places they resemble ordinary ridges of growth. The escutcheon is narrow, steep-sided, and deeply excavated, and the ribs of the flank terminate abruptly at the acute margin which bounds the escutcheon.

#### SUB-GENUS ERIPHYLA F. Stoliczka (? W. M. Gabb).

##### ASTARTE (ERIPHYLA) HERZOGI (Goldfuss).

1840. *Cytherea herzogii* (Hausmann) A. Goldfuss, Petrefacta Germaniæ, Band ii., Lief. 7, p. 239, Tab. cxlix., fig. 10.

1843. *Astarte capensis* F. Krauss, Amtlicher Bericht über die zwanzigste Versammlung der Gesellsch. deutsch. Naturforscher und Aerzte zu Mainz im Sept., 1842, p. 130.
1850. *Astarte herzogii* F. Krauss, Nov. Act. Acad. Cæs. Leop.-Carol. Nat. Cur., vol. xxii., pt. 2, p. 447, Tab. 47, figs. 2a-2e.
1905. *Astarte herzogii* A. W. Rogers, An Introduction to the Geology of Cape Colony, p. 291, fig. 25 (1).

*Occurrence.*—Specimens before me are from the uppermost red bed in a kloof east-north-east of Red House on Zwartkop's River (326, 327), and from a krantz near Picnic Bush, north-east of Red House (328). Messrs. Rogers and Schwarz also found this shell in the cutting on the road running from the farm Perseverance on to the plateau, and leading to the Salt Pan. Stow obtained specimens at McLoughlin's Bluff and between the Addo and Modder Drifts, on the Sunday's River. Hertzog's collection, including this shell, was obtained in the Sunday's River district about eighteen miles from Enon.\* Krauss collected specimens on the left bank of the Zwartkop's River, below Uitenhage.

*Remarks.*—Krauss furnished such an accurate description of this shell that it will only be necessary to supplement this by a discussion of its narrower relationships. *Astarte herzogii* cannot be looked upon as a typical representative of its genus, and it is by no means a simple matter to assign it to its correct position among recognised sub-generic groups. The principal characters to be borne in mind in this connection are as follows. The shell has a lenticular form and frequently an almost circular outline; it is ornamented by crowded concentric ribs and sulcations forming a well-developed sculpture. The lunule is short, but is sharply bounded and of very deep and concave form; the escutcheon is very narrow and elongated, almost entirely occupied by the long ligament space, and very sharply marked off from the flank. In the right valve there is a distinctly developed posterior lateral dental process, situated behind the elongated external ligament, and an anterior (sub-lunular) depression in the hinge-plate for the reception of an anterior lateral process of the left valve. The pallial margin of the valve is strongly notched on its inner side; the pallial line is posteriorly rather weakly impressed.

We are therefore dealing with an *Astarte* in which lateral hinge processes are definitely developed. The evidence for the presence or

\* See Hausmann (1), p. 1459 (as *Cytherea*).



absence of a shallow pallial indentation, it must be admitted, is inconclusive in the material I have examined, but this, after all, is a comparatively minor point, and one of less importance than the nature of the hinge. A fact to be noted is that shells which exhibit a similarly developed hinge are chiefly characteristic of Cretaceous rocks in other regions.

Stoliczka\* thought that *Astarte herzogi* belonged to Speyer's genus *Grotriania*,† but in reality it is widely enough removed from this, which has a very different form and is characterised by a very large and profoundly excavated lunule and escutcheon, and by the absence of lateral teeth. Much closer agreement is shown to the shells known as *Eriphyla lenticularis* (Goldfuss)‡ and other forms to which the name *Eriphyla* has been applied. Unfortunately, the employment of this name has been attended with some confusion. The shell upon which Gabb founded the name (*E. umbonata* Gabb)§ occurs in the Shasta-Chico Series of California,|| and it was thought to be allied to *Astarte*. The characters of the shell were unfortunately not diagnosed with satisfactory precision, and Stoliczka¶ first stated in full detail the distinguishing features of Cretaceous shells (*E. lenticularis*) which he believed to be generically identical with *Eriphyla umbonata* Gabb. Stoliczka, however, brought the genus into relationship with *Dosinia*, though he adduced no convincing reason for such a view, except the presence of a pallial sinus. His description of the hinge characters shows that they agree with those of *Astarte herzogi*, but he mentioned the pallial sinus as a leading feature of his shells, and made no reference to any crenulation of the margin. He says: "It appears probable that some of the Jurassic *Astarte* (*A. excavata* and others) belong to this genus, but a careful examination of the hinge and of the pallial line, which is broad though very faint, and also of its sinus, will be necessary." Again, he remarks: "The hinge-teeth of *Eriphyla* closely approach those of *Astarte*, but these have no distinct lateral teeth, nor a deep lunule or sinus."

Whether Stoliczka did right in ascribing the widely distributed *E. lenticularis* to Gabb's imperfectly characterised genus is a question which still remains unanswered. He, at any rate, used the name in connection with definite and precise diagnostic characters, and his reading has been accepted by Holzapfel,\*\* who maintains

\* Stoliczka (2), p. 286 (1871).

† Speyer (1), p. 496, Taf. xi., fig. 6.

‡ Goldfuss (1), Band ii., p. 228, Tab. cxlvi., fig. 16 (1837).

§ Gabb (1), p. 180, pl. 24, fig. 162.

|| See Diller and Stanton (1).

¶ Stoliczka (2), p. 156 (1870).

\*\* Holzapfel (1), p. 196.

that so long as it cannot be shown that *Eriphyla* Stoliczka differs in essentials from *Eriphyla* Gabb, this name must be retained for shells having the characters set forth by Stoliczka. Previously, however, J. Böhm \* had remarked upon the unsatisfactory nature of Stoliczka's use of Gabb's name, in view of the great uncertainty respecting the characters of the Californian shell, and he employs the name *Dozyia* for *Lucina lenticularis* Goldf., a name applied by Bosquet in 1868 to the same form. Meek † also doubted the correctness of Stoliczka's view in identifying the European and Indian shell with Gabb's genus, but his remarks on the subject only add further confusion and help to show the futility of attempts to utilise Gabb's imperfect description and figure in a generic characterisation.

From the foregoing it appears clear to me that in the absence of further information regarding the Californian type, the published account of Gabb's genus is totally insufficient to support the validity of the name proposed by him; the repeated attempts to utilise Gabb's description and figure have proved so unavailing that the name as based upon Californian material may be reasonably ignored. In further support of this contention it is only necessary to mention that Whitfield ‡ has so conceived the meaning of Gabb's description as to apply the name *Eriphyla* to a Cretaceous shell from Syria which is characterised by triangularly elliptical outline, strongly prominent umbonal region, a short *internal* ligament, and surface sculpture resembling that of *Chione*.

The question then arises, whether the name *Eriphyla* as defined by Stoliczka may be applied to *E. lenticularis*, in view of the fact that Bosquet had previously proposed to call this *Dozyia lenticularis*. It is true that this generic name was only published in a tabular list, § without description or discussion, but it was accompanied by a reference to Goldfuss's type. I should have no hesitation in following Dr. J. Böhm and employing Bosquet's name on the strength of the definite reference to Goldfuss, but unfortunately the description and figure given in the "*Petrefacta Germaniæ*" deals only with external characters, and no mention was made of those features which are of generic or sub-generic value. These were first elucidated by Stoliczka, and herein lies the justification for following Prof. Holzapfel in accepting the name *Eriphyla*, as defined by Stoliczka.

*Eriphyla lenticularis* has a shallow pallial sinus and its valve-margins are not crenulated. It might therefore appear that, on the

\* J. Böhm (1), p. 125.

† Meek (2), p. 123.

‡ Whitfield (1), p. 403, pl. vi., figs. 2-5.

§ Dewalque (1), p. 363.

strength of these points, *Astarte herzogi* should be excluded from this division of the genus, though in reality these characters are of very small value and appear to be sufficiently inconstant to be discarded as guides to the sub-generic grouping. The hinge-characters above described, on the other hand, are remarkably constant in several Cretaceous forms which differ in regard to the marginal crenulation, and it appears that the posterior indentation of the pallial line is only of specific value at the most, appearing occasionally, as in a few other "integripalliate" genera. A shallow pallial sinus is shown to be present in the figures of Aptian shells ascribed by Pictet and Renevier\* to *Astarte buchi* F. Roem. and *A. obovata* J. Sow., and in both of these the margin is crenulate. *Astarte striata* J. de C. Sow., from the Blackdown Beds of England, shows very close agreement with *E. lenticularis*, and, like it, has a shallow sinus and a smooth margin. Then again, the same shell agrees closely in the hinge and other features with *Astarte herzogi*, though the latter has a crenulated margin. This last character, indeed, is clearly one of very small significance. In dealing with *Astarte* and its divisions, von Zittel† has ignored the notching of the margin, while several authorities on the living forms have abandoned this structure as even of specific value.‡ Regarding the value of the distinctive characters of *Eriphyla*, as here accepted, in establishing its claim to the rank of a separate genus, opinions may be expected to differ; I am not convinced that a definite separation from *Astarte* is expedient, or warranted by the features which distinguish *Eriphyla* from typical members of that genus, and I therefore prefer for the present to follow Zittel in employing the name *Astarte* in the broad sense, and including *Eriphyla* as a sub-genus.

In tracing the relationships of *A. herzogi*, it is somewhat surprising to find that the closest agreement is exhibited with shells from the Neocomian of Lincolnshire. These occur in the Claxby Ironstone at Willingham and Benniworth Haven, and are most probably to be assigned to a horizon comparable with a part of the zone of *Belemnites lateralis* or possibly the lowest part of the zone of *Belemnites jaculum* at Speeton;§ specimens are preserved in the Museum of Practical Geology in London, and in the Sedgwick Museum at Cambridge, and have been identified by Mr. Woods as *Astarte laevis* (Phill.).|| The similarity to *A. herzogi* is striking, but the following

\* Pictet and Renevier (1), pl. x., fig. 1; xi., fig. 1.

† Zittel (5), p. 65.

‡ See Jeffreys (1), p. 309.

§ Pavlow and Lamplugh (1), p. 29 (of authors' copy); Pavlow (1), able, p. 548.

|| Woods (3), vol. ii., p. 115 (1906).



points of distinction appear to be constant and to justify the definite separation of these two forms. In the Lincolnshire specimens the shell is as a rule less orbicular, and attains greater height in proportion to length; at the same time, the valve is rather more flattened towards the inferior margin in fully grown individuals. The lunule has greater relative length and is less deeply excavated and less concave in form than in *A. herzogi*. The noticeable fact that the sculpture in the Lincolnshire examples is less well defined than in the African shell may perhaps be in some measure due to the mode of preservation. The form and size of the lunule certainly affords a good separating character, and as regards the outline of the shell, the difference above mentioned seems to hold good if specimens of average proportions be compared, though it must be admitted that *Astarte herzogi* exhibits considerable shape variation, and specimens with shorter and higher outline occur not infrequently.

As already remarked, *Astarte striata* Sow.,\* from the Blackdown Beds, agrees in many respects, but it is a much more compressed and flattened shell, has greater length in relation to height, and shows no marginal crenulation.

*Astarte beaumonti* Leym.,† from the Neocomian of the Aube, is likewise characterised by a sharply demarcated and deeply excavated lunule, and is ornamented by ridges and sulcations similar to those of *A. herzogi*; it may probably agree, too, in the internal characters, but it differs by its inequilateral form and oblique elongation.

*Astarte buchi* F. Roemer‡ (Lower Cretaceous, Perte du Rhône) seems to agree well in internal characters, though it is not clear whether a posterior lateral tooth of the right valve is plainly developed. The sub-lunular groove in the hinge of the right valve, shown in Roemer's figure, seems to indicate the presence of an anterior lateral tooth in the left valve. The sharply cut, elongated escutcheon and the well-sunk short lunule are similar, but Roemer's shell differs from *A. herzogi* by being considerably more inequilateral in shape and also less incurved at the umbones, besides having much less perfectly developed concentric surface sculpture.

*Astarte samanni* de Loriol, from the Portlandian of the north of France § and of England,|| is more similar again, and may be closely

\* J. de C. Sowerby (1), vol. vi., Tab. 520, fig. 1 (1826).

† Leymerie (2), p. 4, pl. 4, fig. 1.

‡ F. Roemer (1), p. 20, fig. 4.

§ De Loriol and Pellat (1), p. 68, pl. vi., fig. 9.

|| Blake (1), p. 232, pl. x., fig. 5.

related. The ornamentation, though coarser, with broader and more widely spaced ribs, is of essentially the same kind, and there is the deeply cut lunule. It may be judged from de Loriol's figure of a left valve that a posterior lateral hinge process is present in the right valve. The shell, while appearing to have very closely similar hinge characters, differs from *A. herzogi* by its more elongated form and relatively less height. English specimens from the Portland Sands of Swindon, ascribed to *A. sæmanni*, have a denser costate ornamentation than the example figured by de Loriol, and in this they more closely resemble *A. herzogi*. Miss E. G. Skeat has drawn attention to the fact that these English specimens, which are well represented in the Sedgwick (formerly Woodwardian) Museum at Cambridge, exhibit a shallow pallial sinus.\*

A shell described by G. Müller under the name *Eriphyla stuhlmanni*, from the Neocomian at a locality 35 km. west of Mtshinga in German East Africa,† clearly belongs to the same sub-generic group. In the characters of the hinge and in the presence of marginal crenulation, it resembles *A. herzogi*, but differs by the absence of the surface ridges and sulcations and by the more inequilateral form and more prominent umbones. *Eriphyla stuhlmanni* is accompanied by a *Gervillia* probably identical with *G. dentata* Krauss. Dr. Müller refers his shell to *Eriphyla* without comment, and was no doubt influenced by the presence of the lateral teeth.

In the orbicular outline, the surface ornamentation and the type of hinge, *Astarte jugosa* (Forbes)‡ from the Upper Cretaceous of the Trichinopoly district (Utatur stage) approaches somewhat closely to *A. herzogi*. The Indian shell was referred by Stoliczka§ to Speyer's genus *Grotriania*, but this was an error of judgment. Its valves, it is true, have a somewhat deepened lunule and escutcheon, but do not compare in this respect with those of the true *Grotriania*, and, moreover, have plainly developed lateral hinge-processes fitting into opposing grooves. In this respect *A. jugosa* agrees with *A. herzogi*, and may be classed in the same sub-division of *Astarte*. According to the description and figures given by Stoliczka, it has a crenulated valve-border and the pallial line is without a sinus. The shell differs from *A. herzogi* by the greater compression of the valves, the greater depth of the escutcheon and hinge-plate, and the more nearly circular outline.

\* Skeat and Madsen (1), p. 124.

† G. Müller (1), p. 553, Taf. xxi., figs. 3, 4; Taf. xxii., figs. 8-10.

‡ Forbes (2), p. 142, pl. xvii., fig. 7.

§ Stoliczka (2), p. 289, pl. x., figs. 12-14.

*Eriphyla argentina* Burckhardt,\* from the Neocomian of Las Lajas (Argentina), is also a similar shell, as regards the hinge, the deep lunule and escutcheon, and the development of concentric ornaments. It differs, however, from *A. herzogi* by the considerably more elongated figure and the coarseness and spacing of the ornamenting ridges. *E. argentina*, it may be observed, has a weak pallial sinus, and Dr. Burckhardt remarks that the margin is probably crenulated.

ASTARTE (ERIPHYLE) PINCHINIANA Tate,

Plate VII., figs. 6, 6a.

1867. *Astarte pinchiniana* R. Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 157, pl. ix., fig. 7.

*Supplementary Descriptive Note.*—The shell has a sub-orbicular outline, with rather acutely pointed, anteriorly directed umbones. The lunule is sharply demarcated from the flank, and is of deeply excavated form, bounded outwardly by a sharp ridge which is concave in profile. The lunule is of relatively great length. The escutcheon is narrow, deep, and sharply bounded, and is occupied very largely by the ligament space.

The valve-surface is ornamented during the neanic stage by numerous and closely crowded, very regular and delicate concentric ribs, terminating posteriorly at the margin of the ligament-space. This ornamentation becomes obscure at a distance of 3–5 mm. below the umbo, and subsequently gives place to numerous delicate, raised growth-lines, too irregular to be confounded with definite sculpture. Stronger ridges and furrows of accretion appear in the late adult stage.

The shell-substance is very thick in relation to the size of the specimens. The interior of the valve-border is strongly crenulate.

<i>Dimensions.</i> —	(1)	(2)	(3)
Height, measured from the umbo	15	18	18 mm.
Length .....	15	18·5	19 „
Depth of a single valve .....	3·5	5	4 „

Number (3) is the specimen figured by Tate.

*Occurrence.*—Collected by Miss Wilman at Coega River. The specimens in the collection of the Geological Society in London are from the Sunday's River.

*Remarks.*—Tate's description and figure of this elegant form must appear sufficiently inadequate when it is realised that a most dis-

\* Burckhardt (2), p. 76, pl. xii., figs. 3–6.



tinctive feature is the very elongated, sharply demarcated and deeply excavated lunule, well preserved and exhibited in the specimen unsatisfactorily figured by Tate. The widely erroneous statements of shell-measurements, so numerous in that author's paper on the South African fossils, are difficult to account for and may best be ignored. Tate's comparison of *A. pinchiniana* with two English Oolitic forms, *A. excentrica* Morr. and Lyc. and *A. pumila* J. de C. Sow., is also unfortunate, since a very much closer resemblance is shown to several Cretaceous forms. *A. excentrica* \* is much more triangular in outline and has the lunule scarcely defined, while *A. pumila* † is a narrow, convex, inequilateral shell widely different in type from the one we are considering.

The question whether *A. pinchiniana* should be referred to the sub-genus *Eriphyla*, as defined by Stoliczka, cannot be decided by an examination of the material which has been at my disposal. In no instance have I been able to ascertain the characters of the hinge, and it is therefore uncertain whether lateral hinge-processes are present in either valve. At the same time, the external characters of shape and the presence of a deep and sharply defined lunule, suggest the strong probability that the arrangement of hinge and lateral teeth is the same as in *Eriphyla*, but it would, of course, be unwise to accept close agreement in external features as justification for a definite conclusion on this point. For the time being, a provisional reference to *Eriphyla* may be permitted. This question might seem to be of subsidiary interest were it not that the known characters of *A. pinchiniana* give this shell so close a resemblance to members of a principally Cretaceous group of forms, and as additional evidence for the age of this fauna, such resemblance must be taken fully into consideration. Remarks on the application of the name *Eriphyla* in dealing with certain Cretaceous forms of *Astarte* will be found above in the discussion concerning the relationships of *Astarte* (*Eriphyla*) *herzogi*.

*A. pinchiniana* differs from immature examples of *A. herzogi* by the relatively more extended lunule and the disappearance of concentric sculpture at the close of the neanic stage. It bears a great outward resemblance to immature specimens of *A. striata* Sow., ‡ having a similarly elongated lunule, with the marginal profile of concave form in front of the umbo; but in *A. pinchiniana* the concentric surface

\* Morris and Lycett (1), part iii., p. 83, pl. ix., fig. 8 (1855).

† J. de C. Sowerby (1), vol. v., Tab. 444, fig. 2 (1824).

‡ Ibid., vol. vi., p. 35, Tab. 520, fig. 1 (1826).

ridges are absent in the adult, and the interior of the valve-margin is strongly crenulated.

*Astarte rhodani* Pict. and Camp.,\* from the "Gault" of the Pertedu-Rhône, is of similar general type, but is truncated posteriorly. Shells from the Gault of Cosne (Nièvre) figured by de Loriol† under the name *A. rhodani* have a much more closely similar, rounded outline; they appear, however, to have a slightly shorter lunule, and they are probably without marginal crenulation.

*Astarte dupiniana* d'Orb.,‡ from the Albian of France, closely resembles *A. rhodani* Pict., and like this, is abruptly truncated posteriorly; in this it offers a contrast to the more rounded profile of *A. pinchiniana*. *A. dupiniana* possesses the character of marginal crenulation, but differs from the African shell in having a less strongly developed lunule and escutcheon.

The presence of well-developed sculpture in the neanic stage of *A. pinchiniana* and its disappearance in the succeeding growth-stages, indicates degeneration, so far as this character is concerned, from a wholly sculptured ancestry.

#### GENUS ANTHONYA W. M. Gabb.

##### ANTHONYA LINEATA sp. nov.

Plate VII., figs. 7, 8.

*Description.*—The shell is of slender, elongated form, much produced posteriorly. The valves are flattened and compressed, having very slight convexity. The umbonal region is not strongly prominent; it is situated at a distance of about one-third of the shell's total length from the anterior extremity, where also the shell has its greatest height. The upper valve-margin, posteriorly to the umbo, slopes down gradually, giving a very slightly concave outline. It has an angular junction with the siphonal margin. The siphonal margin is very short and shows a straight outline, directed slightly posteriorly when traced down to its inferior termination. In front of the umbo, the valve-margin is at first forwardly produced with a downward slope and straight outline, passing then by a curve into the convex anterior margin. This in turn passes by regular curve into the elongated, slightly convex inferior margin. The siphonal

\* Pictet and Campiche (1), 3<sup>e</sup> Partie, p. 319 (1866); Pictet and Roux (1), p. 437, pl. 32, fig. 5 (1852).

† de Loriol (4), p. 94, pl. xii., figs. 1-7.

‡ d'Orbigny (3), p. 70, pl. 264, figs. 4-6 (1844).

margin marks the posterior limit of a weakly defined postero-superior area of the valve-surface. This is only demarcated from the flank by a weak and flattened fold of the surface which passes obliquely backwards from the umbo to the postero-inferior angle of the valve.

The ornamentation consists of very delicate, closely spaced, rounded, concentric ridges, separated by impressed linear interspaces. The ridges traverse the flank, parallel to the pallial border, then turn sharply upwards to cross the area in a direction parallel with the siphonal border. On the area the ornaments are slightly coarser and less regular, and less strongly developed than on the flank.

An internal cast of a left valve shows traces of very weak rounded ribbing, running parallel to the inferior border, but these markings are confined to the middle part of the valve and terminate posteriorly at the oblique, weak carinal ridge. In addition to the two short, diverging, cardinal teeth, there are indications of a narrow, lath-like ridge (represented on the cast by a narrow hollow) running parallel with the upper valve-margin for a short distance in front of the umbo, and another similar narrow depression extends for a longer distance close to the valve-margin behind the umbo. Just above the posterior part of the broadly oval anterior adductor impression, is a small, well-marked, oval pedal muscle-scar. The somewhat elongated posterior adductor impression is situated close to the upper valve-border, half-way between the umbo and the posterior margin, and just below the narrow, lath-like process which is represented on the cast by a groove close to the valve-margin. The pallial line on reaching its posterior extremity turns sharply forward with an angular bend.

*Dimensions.*—

	(1)	(2)
Length .....	15	22 mm.
Greatest height .....	8	12 „

*Occurrence.*—Specimen (1), preserved as a mould of the external surface of a left valve, was found on the left side of the Coega Valley, half a mile down from the railway (461g). Specimen (2), which is the cast of the interior of a left valve, came from a bare slope W. 30 S. from the middle of Barkly Bridge, on the farm Olifant's Kop, Sunday's River (35h).

*Remarks.*—There can be no reasonable doubt that the two specimens above described, showing the exterior and interior characters respectively, belong to one species. They are of interest as representing a genus of shells which is elsewhere only known to occur in rocks of Cretaceous age. These valves have a very delicately



shaped, flattened form, and though their depth cannot be satisfactorily measured in either specimen, it could not have exceeded two or three millimetres. In the example from Olifant's Kop, the pallial border does not lie in a median plane of symmetry, but is laterally bowed, with a slight convexity towards the observer. This may possibly have been an individual abnormally distorted in life, or the distortion may perhaps have been brought about during the process of fossilisation, but it was probably not a normal character.

*Anthonya cultriformis* Gabb,\* the type-species of the genus, from the Cretaceous rocks of California, differs in being considerably more elongated and attenuated posteriorly, and in having more oblique posterior truncation. It also lacks the close linear ornaments which cover the whole surface of *A. lineata*, though it has a similar type of sculpture in the umbonal region.

*A. cantiana* Woods,† from the Folkestone Beds of Folkestone, is more inequilateral, with the umbonal region more elevated and nearer to the anterior extremity. A species described by Mr. Woods, though unnamed, from the Lower Greensand of Atherfield, is distinguished by the posterior elongation and attenuation of its shell, and by its smooth surface.

*Anthonya cornueliana* (d'Orb.)‡ appears to approach more closely in form, especially such a specimen as that figured by Miss Skeat; but *A. lineata* is less inequilateral and is not so obliquely truncated posteriorly.

## GENUS TANCREIDIA J. Lycett.

### TANCREIDIA SCHWARZI sp. nov.

Plate VII., figs. 9, 9a, 10.

*Description.*—The shell has an elongated trigonal outline, well produced anteriorly. The umbonal region is prominent, the margin before and behind it falling away rapidly. The umbo is situated within the posterior half of the valve, though not distant from the middle; it is fairly strongly incurved. The upper margin in front of the umbo forms a straight line in profile, and only curves on reaching the anterior extremity, where it passes by a sudden and sharp bend into the long, gently convex inferior margin. At the posterior end of the short, straight hinge-line the shell-outline is obliquely

\* Gabb (1), p. 182, pl. xxx., fig. 236.

† Woods (3), vol. ii., part 3, p. 130, pl. xix., figs. 4, 5 (1906).

‡ d'Orbigny (3), p. 74, pl. cclxiv., figs. 7-9 (1844), described as *Crassatella*; Skeat and Madsen (1), p. 178, pl. vi., fig. 13 (as *Ptychomya*).

truncated. The oblique posterior border has a sub-angular junction with the inferior border. The greatest height occurs at the umbo. The valves are weakly inflated, most strongly so posteriorly to the middle, and are anteriorly compressed and flattened.

On the posterior side of the valve, a well-marked carinal ridge extends obliquely backwards from the umbo to the posterior angle of the shell, cutting off a narrow, flattened area from the flank. Near the umbo, the surface of the area is directed at right angles to that of the flank, but the angle becomes more obtuse when traced towards the posterior end of the valve. The surface of the area is slightly concave in the neighbourhood of the umbo, but becomes flat posteriorly. The surface of the flank close to the antero-superior margin curves over with a convex surface towards the margin. The surface of the valves is marked only by occasional faint growth-lines.

Immature specimens have a rather more pointed anterior outline than an individual of larger dimensions.

<i>Dimensions.</i> —	(1)	(2)	(3)
Length .....	16	16	22 mm.
Height, measured from the umbo	10	11	15 „
Greatest depth of a single valve	4	4	5 „

*Occurrence.*—In the kloof east-north-east of Red House, on the left side of the Zwartkop's River (324); this form is also found in the Marine Beds of the Sunday's River, where it occurs associated in the same hand-specimen with *Trigonia vau*, *Trigonia conocardii-formis*, *Actæonina atherstoni*, and other characteristic shells. A specimen of this kind is from the collection of the South African Museum. Mr. Rogers collected a fine example of this form from a cliff W. 20 S. from Comley's house, right bank of Sunday's River (95h).

*Remarks.*—The specimens examined are unfortunately so preserved in hard matrix that it has been found impossible to investigate the internal characters. The outward features of the shell, however, are so well marked and so characteristic, that one can scarcely suggest a doubt as to the generic position, unless, indeed, it should happen that we are dealing with a striking instance of parallelism, of which there is so far no evidence. It is with Jurassic forms that the most striking similarities are shown.

This shell may be most aptly compared with familiar English Oolitic forms. *T. extensa* Lycett,\* from the Inferior Oolite, is very

\* Lycett (1), pl. xi., fig. 9; Morris and Lycett (1), part iii., p. 93, pl. xiii., fig. 6 (1855).

similar in outline, but differs in having the umbones more centrally placed, and the posterior carinal ridge less prominently developed and less steeply inclined. The posterior area is narrower, and this and the carinal ridge have greater relative length than in *T. schwarzi*. In the African shell the umbonal angle is sharper and the umbonal region\* more prominently projecting.

*Tancredia brevis* Lycett,\* from the Great Oolite, is also closely similar in form, and may be distinguished principally by its slightly greater convexity, its less prominently projecting umbonal region, and its more pointed anterior outline.

Again, the resemblance shown by *T. schwarzi* to *T. angulata* Lycett,† from the Great Oolite, is very close, particularly in the position of the umbones, the long antero-superior slope of the outline, and the inclination of the carinal ridge; in *T. angulata*, however, the outline is rather more obtuse at the posterior angle, and the aspect of posterior truncation is more marked, while the anterior outline has a rather more pointed form. The resemblance of *T. schwarzi* to these Jurassic types is indeed so striking as necessarily to arrest attention, and it is clear that such a form, if known before, would have been seized upon by those who believed the Uitenhage fauna to be of Oolitic age. How little reliance should be placed on the evidence of a single occurrence such as this is well shown by a study of the associated types, which can only be taken to indicate the Lower Cretaceous age of this fauna. Although the genus *Tancredia* reached its greatest development during Jurassic times, *T. americana* Meek and Hayden‡ is known from Cretaceous strata on the Upper Missouri and on Cache La Poudre River, in Colorado. The generic position of *T. americana* has not been disputed, so far as I am aware, but it is a much larger shell, not closely comparable with the one we are discussing.

A shell from the Upper Aptian of Spain, described by Coquand § as *Tellina gibba*, bears considerable resemblance to some forms of *Tancredia*, and may very well be a representative of this genus, though Stoliczka suggested that it belongs to Gray's *Tellinella*. Coquand himself stated that it differs from other fossil *Tellinæ* by its elongated form and particularly by the strong carinal ridge. Speaking generally, this shell shares the main outward characters of

\* Morris and Lycett (1), part iii., p. 92, pl. xiii., fig. 8 (1855).

† Lycett (2), 341, pl. xiv., fig. 5; Morris and Lycett (1), part iii., p. 94, pl. xiii., fig. 9 (1855).

‡ Meek (2), p. 142, pl. 38, fig. 1.

§ Coquand (1), p. 101, pl. viii., figs. 9, 10.



*Tancredia schwarzi*, from which it differs by its greater elongation and relatively reduced height; it has a more obtuse umbonal angle, and the umbonal region is consequently considerably less prominent.

Although there is also some resemblance to shells which have been ascribed to the genus *Palæomya* Zittel and Goubert,\* *Palæomya deshayesi* Zittel and Goub., from the Corallian, upon which the genus was established, is a more elongated shell and is more inequilateral and less definitely carinated posteriorly. Its umbonal angle is also very much more obtuse. *Palæomya autissiodorensis* (Cott.) de Loriol,† from the Portlandian of the Yonne, while more equilateral and more sharply carinated than the last, is also relatively much more elongated than the African shell, and has much less sloping upper outlines, with inconspicuous umbonal region and obtuse umbonal angle. It may be noted that Miss E. G. Skeat ‡ has referred this Portlandian shell to the genus *Tancredia*, and expressed the belief that these supposed separate genera may have to be united; she points out that they appear to agree very closely both in external and internal characters.

#### GENUS THETIRONIA F. Stoliczka.

##### THETIRONIA PAPYRACEA (Sharpe).

Plate VII., figs. 11, 11a.

1856. *Ceromya papyracea* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 195, pl. xxii., fig. 8.

*Supplementary Description.*—The shell is of rounded sub-quadrate or oblong outline, with the length slightly greater than the height; it is strongly inflated in the umbonal half. The umbones are strongly incurved and are anteriorly directed; they are situated at a distance of less than one-third of the shell's total length from the anterior margin. The hinge-line is only very slightly curved and has a scarcely perceptible downward slope when traced backwards from the umbo, passing posteriorly by a somewhat abrupt curve into the elongated posterior margin; this margin, also, is only very slightly convex in profile and gives the shell an aspect of vertical posterior truncation. The lower border forms a gently convex profile. There is no keel on the posterior side of the valve.

The surface of the very thin shell is ornamented by numerous,

\* Zittel and Goubert (1), pl. viii., figs. 6-8.

† de Loriol and Cotteau (1), p. 510, pl. v., figs. 12-14.

‡ Skeat and Madsen (1), p. 129.

delicate, radial, linear striæ, which at the lower margin of an adult, and especially in the posterior half of the valve, may be separated by spaces exceeding a millimetre in breadth. The granular ornaments which occur on the striæ are delicate though prominent, and widely spaced (nearly 4 mm. apart on the same radial line) towards the lower margin in the posterior half of the valve, but less conspicuous and much more closely spaced in the anterior half.\* The radial striæ leave their impression on the cast when the thin shell becomes removed.

The well-impressed line on the posterior side of a cast, passes far up and has its angular apex situated close to the umbonal apex. Its anterior limb becomes weakly impressed when traced downwards from the angle for a distance of 7 mm. or 8 mm., and appears to dwindle and disappear at its lower end instead of bending forwards as a well-defined line. On the anterior side of the cast there is a single radial linear impression, less clearly defined than those of the posterior side; it appears most clearly marked at a distance of about 6 mm. from the umbonal apex, and dies out on entering the lower half of the valve.

<i>Dimensions.</i> —	(1)	(2)	(3)
Length .....	22	25	47 mm.
Height measured from the umbo	19	22	30 „
Greatest depth of a single valve...	8	10	11 „

Number (3) is the specimen figured by Sharpe.

*Occurrence.*—Collected in the railway cutting between milestones 24½–24¾ on the line from Uitenhage to Graaff-Reinet, about three miles from Uitenhage (315); also found by Miss M. Wilman at Coega. The locality given by Sharpe is “Zwartkop River.”

*Remarks.*—Sharpe referred this shell with some doubt to the genus *Ceromya*, and he evidently had not the opportunity of observing the characters of the cast, which would have set at rest all doubts as to a generic determination. In addition to the well-impressed angular line on the posterior side of the umbonal region of the cast, the thin shell and the surface markings afford additional indications of generic position. In the fine specimen collected by Bain and figured by Sharpe, the shell is so preserved that the delicate ornaments of the surface are obscure, and their presence only becomes clearly evident when the specimen is very carefully examined in a good light under slight magnification. The specimen from Coega,

\* It may, perhaps, be more correct to speak of some of these markings as punctations, each of which has a well-raised circular rim; they represent the bases of very short spines.

figured here, is so well preserved that these surface characters are plainly visible to the naked eye.

The occurrence of a representative of this exclusively Cretaceous genus has considerable interest when regarded as additional evidence for the age of this molluscan fauna. It is perhaps fortunate that the shell before us, when well preserved, is sufficiently characterised by its own distinctive form to preclude confusion with European members of the genus, especially as the nomenclature of these has for so long been in an unsatisfactory state. The European forms appear to show considerable variation, and are often preserved merely as casts, while the delicacy of the shell renders it liable to distortion, and true characters of similarity or difference are, therefore, often difficult to establish. In like manner, immature or ill-preserved specimens of *Th. papyracea* may seem to differ somewhat widely from the large individual figured by Sharpe, and may appear to approach some of the European forms; hence, a brief comparison with certain of these may perhaps be not without value.

The shells from the Blackdown Beds described under the name *Corbula lævigata* by Sowerby\* seem to represent the same form as that afterwards named *Thetis major*,† while some shells from the Lower Greensand of Atherfield (Isle of Wight) cannot always be satisfactorily distinguished from small specimens of the Blackdown form. Others from the Lower Greensand in the Isle of Wight, named *Thetis minor* by the same author,‡ are frequently preserved as casts (the specimens from Shanklin), but appear to be usually well distinguished from those above-mentioned by their greater convexity, their more prominent umbones, and frequently straighter and longer hinge-line. Some individuals, however, are very difficult to separate, and Roemer§ united these two forms under the name *Thetis sowerbyi*. Forbes, again, divided Roemer's *Th. sowerbyi* into varieties *minor* and *major*;|| but these are both regarded by Mr. Woods as synonymous with J. de C. Sowerby's *Thetis minor*. Mr. Woods also considers that d'Orbigny's *Thetis lævigata* is identical with Sowerby's *Th. minor*. Despite some difficulty in the comparison of certain individuals, we may on the whole satisfactorily distinguish between *Thetironia lævigata* (J. Sow.)—which includes *Th. major* (J. de C. Sow.)—and *Th. minor* (J. de C. Sow.), which includes *Th. lævigata* (d'Orb.)

\* J. Sowerby (1), vol. iii., Tab. 209, figs. 1, 2 (1818).

† J. de C. Sowerby (1), vol. vi., Tab. 513, figs. 1-4 (1826).

‡ Ibid., vol. vi., Tab. 513, figs. 5, 6 (1826).

§ F. A. Roemer (2), p. 72 (1841). || Forbes (1), 242.



*Thetironia papyracea* is distinguished from *Th. lævigata* by its greater inflation, its anteriorly situated umbones, its posterior truncation, and the absence of strong radial striæ on the posterior side in the neighbourhood of the cardinal margin. It is widely separated from *Th. minor* by its inequilateral form and long, truncated posterior margin, and apparently also by the obscure lower termination of the anterior limb of the angular line impressed on the cast.

The Cenomanian shell ascribed by d'Orbigny to *Thetis major*, which was renamed *Thetis rotomagensis* by Pictet and Campiche, is much more equilateral, and appears to have the umbonal region less prominent and less inflated than in *Th. papyracea*, and if d'Orbigny's figure be correct, the angular line on the cast does not extend so far up towards the umbonal apex. The anterior limb of the line is also bent forwards at its lower end and passes in well-defined manner across the flank.

*Thetironia renevieri* (de Loriol),\* from the Hauterivian of Sainte-Croix and Mont Salève, has a general outline and degree of convexity somewhat approaching that of *Th. papyracea*, but the Swiss shell has the limbs of the angular line of the cast much more widely diverging, and the anterior limb forwardly bent and passing relatively closely to the anterior valve-margin when traced downwards; it is also more equilateral, with much greater height in relation to length.

*Thetironia genevensis* (Pict. and Roux),† which occurs in the "Gault" of the Perte-du-Rhone, Cosne, Sainte-Croix, and other places, is distinguished by its more equilateral and more circular outline, and by the form of the angular line on the cast, though it approaches *Th. papyracea* in its inflation and in the prominence of the umbonal region. *Thetironia prestensis* (Pictet and Campiche)‡ (Aptian) lacks the elongation and posterior truncation that characterises *Th. papyracea*, and its linear markings on the cast follow a widely different course.

*Thetironia sanctæ-crucis* (Pict. and Camp.) is still further removed from the African shell, not only by its outline, but especially by the great relative breadth and shallowness of the posterior sinus on the cast.

A shell which much more closely approaches *Th. papyracea* in the general form and outline and in the position of the umbones is

\* de Loriol (1), p. 65, pl. ix., fig. 11.

† Pictet and Roux (1), p. 420, pl. xxx., fig. 2 (1852).

‡ Pictet and Campiche (1), 3<sup>e</sup> Partie, p. 205, pl. cxii., fig. 6 (1865).

*Th. caucasica* (Eichwald),\* from "Greensand" in Daghestan, said to be of Gault horizon. When compared with other representatives of the genus, this, like the African form, is of relatively elongated outline; but in *Th. caucasica* the shell is slightly more equilateral and the posterior border is not so abruptly truncated as in *Th. papyracea*, but is more convex in profile, while the course followed by the anterior limb of the angular line on the cast is a different one.

Although the true systematic position of the genus *Thetironia* cannot yet be said to be established beyond doubt, it is clear that the angular linear marking on the internal casts in no degree coincides with the course of the pallial line. The genus has therefore been erroneously held to be related to members of the Veneridæ, but although its suggested affinity to the Lucinidæ seems to accord better with what is known of its characters,† yet the evidence for such relationship is not of a satisfactory character. Mr. H. Woods, who has examined some material which is very favourably preserved for the purpose of comparative study, has found points of analogy between *Thetironia* and *Protocardia*, both in the characters of the hinge and the ornamentation; but after drawing attention to some features which distinguish these genera, and carefully weighing the available evidence, Mr. Woods concludes that "although *Thetironia* resembles the Cardiidæ in several respects, yet the points of difference are too great to allow of its being included in that family." ‡

THETIRONIA OBLONGA sp. nov.

Plate VII., figs. 12, 12a, 12b.

*Description.*—The shell is of elongated form, with the length considerably greater than the height. The umbones are situated a short distance anteriorly to the middle of the shell and are fairly well raised and prominent and are strongly incurved. The cardinal margin is very long and is only slightly curved, falling very gently when traced forwards from the umbo and still more gradually posteriorly to the umbones. The greatest height of the shell is at the umbonal part. The height near the posterior end of the shell is greater than in the anterior quarter. In lateral aspect, the cardinal margin is seen to pass by a curve into the posterior margin, which

\* Eichwald (1), p. 709, pl. xxvi., fig. 7; Anthula (1), p. 90, Taf. iv., fig. 6.

† See remarks on this point by Miss E. G. Skeat; Skeat and Madsen (1), p. 177.

‡ Woods (3), vol. ii., part 4, p. 167 (1907).

at once falls very steeply with very gently convex outline. This passes in turn by a curve (broader than that of the postero-dorsal outline) into the inferior margin, which has an almost straight outline. The short frontal border has an evenly convex outline. The shell is greatly inflated below the umbonal region, but the valves are compressed in the neighbourhood of the posterior border.

The outer surface of the very thin shell-wall, so far as it has been observed, appears to show only the faintest traces of radial striæ, but delicate radial linear markings are to be seen on the surface of a cast of the interior. The punctate ornaments of the surface may be separated from one another, on the same radial line, by a space of at least 3 mm. in the posterior part of the shell, near the pallial margin. They are less strongly developed and are more closely spaced in the anterior part of the valves.

The well-marked angular linear impression on the posterior side of the umbonal region of the internal cast, has its apex extending almost to the umbonal apex, so that the apical part of the angular line is hidden from view by the incurvation of the contiguous umbones, in a specimen in which the valves are united. The line forms a very acute angle. The posterior limb is relatively weakly impressed, but the anterior limb is well incised and has a very slight backward inclination when traced away from the umbonal apex. In the specimen here described, it only extends for about 5 mm. and then ceases abruptly, while the posterior limb extends for at least 8 mm. and dwindles away.

*Dimensions.*—

Length .....	25 mm.
Height, measured from the umbo .....	17 „
Greatest depth of a single valve .....	9 „

*Occurrence.*—Collected at a kloof, S. 5 W. from Comley's house, on the right bank of Sunday's River (83h).

*Remarks.*—Only one specimen of this form has been found, but it is well characterised by its long cardinal and pallial margins and the relatively small height in comparison with length, as well as by the peculiar form of the angular linear impression on the cast in the umbonal region. The specimen is preserved in the form of an internal cast with portions of the shell adhering, and it is not in the least distorted. So far as I am aware, there is no described species of *Thetironia* with which this new form can be brought into close comparison.



## GENUS TRAPEZIUM Megerle von Mühlfeldt.

TRAPEZIUM? TATEI sp. nov.

Plate VII., figs. 13, 13a.

*Description.*—The shell is well elevated in figure, with the umbonal region rising prominently, and well removed from the anterior extremity. The cardinal margin is almost straight posteriorly to the umbo, and slopes back to form a rounded obtuse angle with the straight, very steeply falling posterior border. In front of the umbo the margin falls rapidly, with slightly convex outline, to the sharply convex anterior border. The inferior margin gives a broadly convex outline, and has a sharply angular junction with the posterior border. The greatest height occurs at the umbo, the greatest convexity at about the middle of the valve.

On the posterior side of the valve a sharp carinal ridge passes in steeply inclined direction from just behind the umbonal apex to the postero-inferior angle of the valve-margin. This carina marks off a very well-defined, flattened posterior area, the surface of which is inclined at a sharp angle to that of the remainder of the valve. The valve-surface is devoid of sculpture, but is marked by numerous delicate lines of growth.

*Dimensions.*—

	(1)	(2)
Length .....	9.5	14 mm.
Height .....	8	12 „
Depth of a single valve .....	—	4 „

*Occurrence.*—Found on the left side of the Coega Valley, half a mile down from the railway (452g). An imperfect left valve, apparently of the same species, occurring in the same hand-specimen with *Solecurtus* sp. and *Meretrix uitenhagensis* (310), was found at Grass Ridge, three miles east-north-east of Uitenhage.

*Remarks.*—Unfortunately there is only a single perfect specimen, a left valve, available for description, but this is very well preserved, although the interior characters cannot be studied.

Another shell of still more doubtful generic position, with which this form is comparable in some respects, is *Corbula? rockiana* Tate.\* The general habit is very similar, but a very careful comparison with Tate's type-specimen (number 11023 in the collection of the Geological Society) seems to preclude any idea of uniting these two forms. Tate's species is less elongated, more elevated in figure, and considerably more inflated, particularly in the umbonal region,

\* Tate (1), p. 159, pl. viii., fig. 8.

and its carina falls more steeply and forms a line more nearly straight. In *Trapezium*? *tatei*, the carina follows a more oblique direction and forms a more curved line when the valve is viewed in lateral aspect. In *Corbula*? *rockiana* the umbonal region is broader and more massive, and the incurvation more pronounced. It may be remarked that Tate's figure of *Corbula*? *rockiana* is not accurately drawn. The figure gives the idea that there is a depression or concavity on the surface of the valve, whereas this is really not the case in the specimen itself.

A shell of apparently very similar type, so far as external characters go, has been described by G. Müller\* from the Lower Cretaceous of German East Africa as *Mactra stromeri*. Another comparable form when large specimens are selected is *Mactra*? *angulata* J. de C. Sowerby, from the Blackdown Beds of England.† This, however, is less produced in front and the umbonal region is not so prominently developed and is less incurved. The umbo in *Trapezium*? *tatei* is more anteriorly placed and more forwardly directed.

Owing to the scanty material available for study, and the fact that the nature of the interior is at present unknown, the generic position of this shell cannot be satisfactorily settled, although the provisional assignment to *Trapezium* may, perhaps, not prove incorrect. It seems possible, however, that this may be a member of the group, typified by *Cypricardia bathonica* d'Orb.,‡ of the Great Oolite, for which Fischer has proposed the name *Pseudotrapezium*,§ although there can be no certainty on this point.

## GENUS CYPRINA Lamarck.

### CYPRINA RUGULOSA Sharpe.

1856. *Cyprina rugulosa* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 195, pl. xxii., fig. 9.

*Occurrence*.—This characteristic form was obtained from the green sandy beds, crowded with the remains of oysters, in the cliff below the old school-house at Dunbrodie, Sunday's River (325). Sharpe recorded it from "Sunday River, in greenish shelly grit," and Stow mentions its occurrence above the Modder Drift on the Sunday's

\* G. Müller (1), p. 563, pl. xxv., fig. 15.

† J. de C. Sowerby (2), p. 341, pl. xvi., fig. 9.

‡ Morris and Lycett (1), part ii., p. 75, pl. vii., fig. 8 (1853).

§ Fischer (1), fasc. xi., p. 1075 (1887).

River, in association with the characteristic *Trigoniæ* of the Marine Beds. In 1905 Mr. Rogers found this species in the cliff on Buck Kraal, Sunday's River (128h).

*Remarks.*—*Cyprina rugulosa*, in its inflated character, the position of the umbones, and the wrinkled surface, bears no slight resemblance to *C. regularis* d'Orb.,\* from the lower Gault of Europe; it differs chiefly in the manner in which the upper margin slopes away posteriorly into the posterior margin. The European form has greater relative height at its posterior end, with an accompanying aspect of truncation.

Some individuals of *C. rugulosa*, in which the shell attains a rather greater height in proportion to length than in the majority of specimens I have examined, approach somewhat closely in form to a *Cyprina* recorded by Dacqué from strata of supposed Aptian age in Somaliland;† but *C. rugulosa* is less strongly inflated, and most examples are further distinguished by their rough surface markings.

#### CYPRINA BORCHERDSI Tate.

1867. *Cyprina borcherdsi* R. Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 161, pl. viii., fig. 2.

*Occurrence.*—Found in the railway cutting between milestones 24½–24¾ on the line from Uitenhage to Graaff-Reinet, about three miles from Uitenhage (313). The specimens described by Tate were also from the Zwartkop's River.

A specimen obtained by Mr. Rogers from the left side of the Coega Valley, half a mile down from the railway (467g), must also be referred to the same species.

*Remarks.*—Tate's type-specimen is unfortunately inaccurately figured, and is represented as considerably more elongated than it really is. It measures 42 mm. in greatest length and 31 mm. in height, while the corresponding measurements of the illustration in Tate's paper are 47 mm. and 27 mm. respectively. The greatest depth (convexity) of this type-specimen (a single valve) is about 10 mm. A specimen obtained by Messrs. Rogers and Schwarz is an immature individual measuring 17 mm. in height; it is imperfect anteriorly, and consequently has the aspect of being more equilateral than Tate's shell, though a careful comparison leaves no doubt about its identity.

\* d'Orbigny (3), p. 100, pl. 272, figs. 3–6 (1844); Pictet and Campiche (1), 3<sup>e</sup> Partie, p. 224, pl. cxv., figs. 1, 2 (1865).

† Dacqué (1), p. 16, Taf. ii., fig. 9.



I have been unable to ascertain the nature of the hinge, and must regard the generic determination of this form as provisional. A shell having very similar outward form is *Cyprina swindonensis*, described by the late Prof. Blake\* from the Portlandian Swindon Sands of England.

GENUS MERETRIX Lamarck (*sensu lato*).

MERETRIX UITENHAGENSIS sp. nov.

Plate VII., figs. 14, 14a; VIII., figs. 1, 1a.

*Description.*—The shell is of somewhat variable ovate outline, with the umbones situated at about one-third (or slightly less) of the shell's total length from the anterior extremity. The shell-substance is relatively thin and the aspect of the valves considerably compressed and flattened, particularly in the lower half of the individual. The cardinal margin slopes down only very gently when traced back from the umbo, giving a slightly convex outline, and passes by a curve into the posterior border which is evenly convex in outline, or most sharply curved towards the lower part. This border usually has considerably greater extent than the frontal border, which is more sharply curved and limited in height by the somewhat rapid convergence of the upper and lower borders in front of the umbo. The inferior border gives an evenly convex outline. The umbones are little-prominent and gently incurved; they share in the relatively compressed character of the shell. The greatest height of the valve occurs a little posteriorly to the umbo.

The surface is covered with very minute and delicate, concentric, raised linear ornaments, separated by narrow, thread-like striæ; in the lower half of the valve there are about eight of these raised lines within the space of a millimetre. The lines are not all of equal strength, nor are the interspaces equal in breadth, yet they have a much greater aspect of regularity than that shown by mere striæ and ridges of growth. Behind the umbones, the flank of each valve passes over into the well-sunk ligament space without carination, but forming a rounded, blunt, pillow-like margin which, when observed in profile, conceals the ligament. The ligament (preserved in some specimens) in an individual measuring 14 mm. in length, extends back from the umbones for a distance of 5 mm.

\* Blake (1), p. 232, pl. x., fig. 2.

<i>Dimensions.</i> —	(1)	(2)	(3)	(4)
Length .....	14	16	17	20 mm.
Height, measured at the middle of the valve	11	12	13	16 „
Greatest depth of a single valve .....	3	3.5	3.5	4 „

*Occurrence.*—Found in the kloof east-north-east of Red House, on the left side of the Zwartkop's River (324), and at Grass Ridge, three miles east-north-east of Uitenhage (310); also in the railway cutting between milestones  $24\frac{3}{4}$ – $24\frac{3}{4}$  on the line from Uitenhage to Graaff-Reinet, about three miles from Uitenhage (316). A specimen sent from the South African Museum is from the Sunday's River, occurring with *Holcostephanus* cf. *atherstoni* (Sharpe). Mr. Rogers obtained specimens of this form, in 1905, from the left side of Coega Valley, half a mile down from the railway (453g, 454g); from a bare slope, W. 30 S. from the middle of Barkly Bridge, on the farm Olifant's Kop, Sunday's River (24h, 26h, 28h–30h); and from the highest beds in the kloof behind Colchester, left bank of Sunday's River (493g, 498g).

*Remarks.*—Although this elegant shell shows some variation in outline and in the degree of inflation, yet the individuals here brought together agree on the whole very closely and are well characterised. The chief features of the shell are the generally rounded and soft outline, the inconspicuous, rounded umbonal region, and the very compressed form of the valves.

In outline, the shell resembles some specimens of *Venus orbignyana* Forbes,\* from the Lower Greensand of the Isle of Wight, which differs, however, by the considerably stronger inflation and the more marked anterior excavation under the umbones. *Meretrix uitenhagensis* has a less steeply sloping upper margin posteriorly to the umbones, and the umbones are less prominent. The minute concentric linear striæ are developed also in *Venus orbignyana*, though more faintly marked than in the African shell.

*Meretrix parva* (Sow.),† also from the Lower Greensand of England, is more circular in outline, more nearly equilateral, and considerably more inflated in form.

*Meretrix brongniarti* (Leymerie)‡ is a larger and more massive shell, and even if compared at the same dimensions is seen to be more elongated and posteriorly attenuated in outline, and more equilateral.

\* Forbes (1), p. 240, pl. ii., fig. 5.

† J. de C. Sowerby (1), vol. vi., Tab. 518, figs. 4–6 (1826).

‡ Leymerie (2), p. 5, pl. v., fig. 7; pl. vii., fig. 1.

*Meretrix labadyei* (d'Archiac),\* from the Tourtia of Tournay, has an almost identical outline, but its valves are much more convex. The same character distinguishes several other Cretaceous forms ascribed to *Cytherea* or *Venus*, which, when compared with our shell, are seen to have a very similar outline.

In the shape of the shell, the inconspicuous umbones, and the compressed form, resemblance is shown to *Tapes picteti* de Loriol,† from the Gault of Cosne (Nièvre), which, however, is not so elongated relatively to height, and moreover, has a coarser concentric ornamentation. A similar resemblance is shown to *Tapes patagonica* Stanton,‡ from the Belgrano beds (Lower Cretaceous) of Patagonia, but the points of distinction are plainly seen in the less elongated figure, the greater inflation, and the coarser concentric ornamentation of the Patagonian shell.

A shell from supposed Lower Cretaceous strata in the Cameroons (left bank of Mungo River), described by von Koenen§ as *Cytherea wohltmanni*, differs from *Meretrix uitenhagensis* in the greater inflation, the more inequilateral form, and the prominence of the umbonal region.

A word may be added regarding the generic position of this form. In no specimen has the interior been seen, so that a precise generic determination cannot really be made with certainty; but a comparison with other species in which the hinge-teeth are known, justifies a provisional reference to *Meretrix*, if this name be applied in the broad sense in which the name *Cytherea* has for long been used, with reference to Cretaceous forms. The tendency of modern work is to set closer and closer limits to the application of long-established generic names amongst lamellibranchs, as in other classes of Mollusca. It is highly probable, when evidence of internal characters can be obtained, that an extension of this principle to Cretaceous forms, on the lines carried out in the classification of recent and Tertiary species, may eventually show the inapplicability of the name *Meretrix* (equivalent to *Cytherea* as commonly used) to such a form as the one here described. From practical considerations, however, it will often be necessary, as in the present case, to continue to utilise in a broad sense a name which, though perhaps technically wrong, conveys as definite a meaning as the available evidence for the time being allows.

\* d'Archiac (1), p. 303, pl. xiv., fig. 7. † de Loriol (4), p. 64, pl. vii., fig. 21.

‡ Stanton (3), p. 23, pl. iv., figs. 12, 13.

§ von Koenen (1), p. 36, Taf. iv., figs. 6, 8, 9; since shown to be of Upper Cretaceous age, see Solger (1).



## GENUS PSAMMOBIA Lamarck.

## PSAMMOBIA ATHERSTONI Sharpe.

1856. *Psammobia atherstoni* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 196, pl. xxii., fig. 11.

This was found in the cliff below the old school-house at Dunbrodie, on the right bank of Sunday's River (321, 325). A specimen from this locality, submitted to me, agrees very closely with the largest individual figured by Sharpe. The Dunbrodie specimen measures 25 mm. in length and 15 mm. in height; it is a left valve, having the characteristic compressed form and flattened flank and very inconspicuous umbo. Sharpe records this shell from the "Sunday River near Enon, in a grit sometimes full of the casts of the shell." At Dunbrodie *Psammobia atherstoni* is associated with *Actæonina atherstoni*, *Turbo atherstoni*, *Pecten cottaldinus*, and other forms. Messrs. Rogers and Schwarz mentioned the occurrence of *Psammobia atherstoni* in the Wood Bed series of the Bezuidenhout's River below Blue Cliff,\* but this name was probably applied to specimens which I have referred to the genus *Unio*.

The generic determination of this species must be regarded as provisional. No specimens showing satisfactorily the internal characters have been available for study, and true relationship with *Psammobia* (or *Gari* Schumacher, if this be regarded to have synonymic value) still remains to be proved. The propriety of considering the name *Gari* to possess the same significance as that which has been ascribed to *Psammobia* (sensu lato) is perhaps still open to question. The shells we are dealing with in the present instance are smooth and without radial markings, and this fact, together with the slight doubt concerning even the broader generic relationships, seems to justify the retention, for the time being, of Lamarck's more familiar and more widely accepted name. It appears reasonable, under the circumstances, to use as a provisional measure a nomenclature which clearly indicates the supposed relationships, though it may perhaps be technically erroneous. To hazard a "correction" of nomenclature on an insecure basis of imperfect knowledge is a step for which it would probably be more difficult to find justification.

\* Rogers and Schwarz (1), p. 13.

GENUS SOLECURTUS H. D. de Blainville.

SOLECURTUS sp.

Text-figure 1.

*Description of a Single Specimen.*—The specimen is a right valve, slightly imperfect at the siphonal margin. The umbo is very inconspicuous, and is situated slightly in front of the middle of the shell. The upper margin slopes down very gently in front and behind the umbo. The frontal margin is short and has a rounded convex profile; towards this margin the upper and lower valve-borders very gently converge. Towards the siphonal margin the valve has a slightly greater height than in the anterior half. The surface is marked by lines of accretion, but no trace of ornamentation has been observed. The inflation of the valve is very slight.



FIG. 1.—*Solecortus* sp., nat. size. Survey Collection.

*Dimensions.*—

Length (if restored).....	31 mm.
Height at the umbo.....	12 „
Depth of the valve, about .....	3 „
Length of siphonal margin.....	9 „
Length of frontal margin .....	6 „

*Occurrence.*—Found at Grass Ridge, 3 miles east-north-east of Uitenhage (310).

*Remarks.*—The single specimen examined is not quite complete at the posterior end, and, unfortunately, the surface is so preserved as to leave no traces of faint linear sculpture, if such markings were ever present. By following the growth-lines it is possible to arrive at the original form of the posterior border. In shape the shell agrees very closely with *Solecortus warburtoni* Forbes,\* from the Aptian of Atherfield (Isle of Wight); the umbo occupies a similar position, and the valve is anteriorly rounded, with diminished height towards the frontal border, while posteriorly the height is greater. The only clearly observable difference is that, in specimens of similar dimensions, the measurement from the umbo vertically to the inferior margin is relatively rather smaller in the English shell.

\* Forbes (1), p. 237, pl. ii., fig. 1.

This also has very faint and delicate radial, linear ornamentation on the anterior part of the flank, but the African shell may originally have borne similar minute sculpture, and on this point nothing further can at present be said.

Similar forms were described by d'Orbigny, under the name *Solen*, from the Lower Cretaceous (*S. robinaldinus*)\* and from the Chalk (*S. æqualis*).† Guéranger has figured a shell from the Cenomanian of the Sarthe under the name *Solecurtus æqualis*,‡ to which our specimen appears to bear a close resemblance, so far as comparison is possible.

#### GENUS MACTRA Linn.

MACTRA? DUBIA sp. nov.

Plate VIII., figs. 2, 2a, 3, 3a.

*Description*.—The shell has greater length than height, and the umbones are situated at rather more than one-third of the shell's total length from the anterior extremity. The inflation is moderate, and most strong just above the middle of the valves. The umbones are somewhat weakly developed and are not very prominent. The cardinal margin and the posterior margin form together a curved outline which passes down, posteriorly very steeply, to a marked angular junction with the lower border. From the umbo a well-marked carina passes obliquely across the posterior part of the valve, down to the postero-inferior angle of the valve-margin. The carina marks off a flattened or very slightly concave postero-superior area which occupies less than one-quarter of the total valve-surface. In front of the umbo the valve-margin slopes down to form a somewhat sharply curved outline in front, the foremost point of the anterior margin falling well within the lower half of the shell. The long pallial margin shows a broadly convex outline, sometimes slightly flattened towards the posterior end. The greatest height of the valve occurs at the umbonal part. The surface is smooth, with numerous delicate growth-lines, and shows closely spaced radial rows of very minute punctæ, only visible under a lens.

<i>Dimensions</i> .—	(1)	(2)
Length .....	15	15 mm.
Height, measured from the umbo	12	12 „
Greatest depth of a single valve	4	3.5 „

\* d'Orbigny (3), p. 320, pl. 350, figs. 1, 2 (1845).

† d'Orbigny (3), p. 321, pl. 350, figs. 5-7 (1845).

‡ Guéranger (1), pl. xv., fig. 3.



*Occurrence*.—Found in the cliff on Buck Kraal, Sunday's River (141h).

*Remarks*.—The doubtful reference of this form to *Mastra* is, it must be admitted, unsatisfactory. The generic position, in fact, is very uncertain, for the characters of the hinge are unknown and the ligament space is relatively extensive. The general aspect of the shell does not accord well with either *Cyprina* or *Meretrix*. The specimens share with *Mastra angulata* J. de C. Sow. (Blackdown Beds),\* the sub-angular junction of the posterior and inferior margins and the presence of a defined ridge running obliquely from the umbo down to the base of the posterior margin. In *M. angulata*, however, the shell is more triangular and less ovate in outline, and the umbonal region is more prominent and tumid, less anteriorly placed, and less strongly directed forwards.

*Mastra warrenana* Meek and Hayden (Cretaceous of Dakota) † is in some degree comparable, but differs by its more trigonal form, more prominent umbonal region, and the presence of a defined lunule of relatively large size.

#### GENUS PLEUROMYA L. Agassiz.

##### PLEUROMYA BAINI (Sharpe).

Plate VIII., figs. 4, 4a.

1856. *Myacites? bainii* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 195, pl. xxii., fig. 7.

*Occurrence*.—The locality given by Sharpe was merely "Sunday River." Specimens were collected by Messrs. Rogers and Schwarz at Grass Ridge, 3 miles east-north-east of Uitenhage (317, 318, 334, 335), from an outcrop of nodular limestone, the highest fossiliferous outcrop of this locality, where many characteristic fossils of the Sunday's River Beds were found. ‡ *P. baini* was also found to occur commonly in the railway cutting between milestones 24½–24¾ on the line from Uitenhage to Graaff-Reinet. Mr. Rogers obtained a very well-preserved specimen from the highest beds in the kloof behind Colchester, Sunday's River Valley (495g).

*Remarks*.—There is some variation in the form of the shell, and the inferior margin, though never showing a strongly curved outline, is not always so straight as depicted in Sharpe's figure. When well

\* J. de C. Sowerby (2), p. 341, pl. xvi., fig. 9.

† Meek (2), p. 208, pl. xxx., fig. 7.

‡ Rogers and Schwarz (1), p. 9.

preserved the surface is seen to be covered with closely spaced radial lines of delicate granules.

Although possessing no highly distinctive external features, this shell retains a certain characteristic aspect, while approaching somewhat closely to some European representatives of the genus. It may usually be easily distinguished from the larger *Pleuromya lutraria* (Krauss),\* another characteristic shell of the Sunday's River Beds, with which it is associated. If mature specimens be compared, *P. lutraria* is distinguished by its much larger dimensions. If small specimens of this be brought into comparison with mature examples of *P. baini* of equal size, there is a considerable general similarity between them; but *P. lutraria*, when young, has a definite ornamentation of rounded concentric ribs, whereas *P. baini* is a smooth shell, with the surface only marked by lines of growth and minute granules. The umbones of *P. lutraria* are rather more prominent, and are perhaps situated a little nearer to the anterior extremity, while the margin in front of the umbo slopes down more suddenly than in *P. baini*.

*Pleuromya neocomiensis* (d'Orb.)† is a similarly elongated form, but is distinguished by marked anterior truncation. *P. rostrata* (d'Orb.)‡ is more produced posteriorly and has a more curved inferior outline. Some individuals of *P. baini* closely resemble a *Pleuromya* from the Lower Greensand of the Isle of Wight which has been considered, apparently erroneously, to represent d'Orbigny's *P. neocomiensis*, and is much more likely to be identical with *P. schröderi* (Wollemann),§ from the Neocomian of North Germany. To judge from Dr. Wollemann's description and figure, *P. schröderi* approaches very closely indeed to *P. baini*.

Another shell which shows considerable resemblance to *P. baini* occurs in the Neocomian sandstone of the Teutoburger Wald, and was ascribed by Weerth,|| though perhaps erroneously, to d'Orbigny's *Panopæa neocomiensis*; the general similarity is great, but the shell figured by Weerth has an inferior margin presenting a rather more curved outline.

The shell from the Neocomian of North Germany, described by F. A. Roemer¶ as *Pleuromya solenoides*, is an elongated form with

\* Krauss (2), p. 447, Tab. xlvii., fig. 1.

† d'Orbigny (3), p. 329, pl. 353, figs. 3-8 (1845).

‡ d'Orbigny (3), p. 333, pl. 355, figs. 3, 4 (1845).

§ Wollemann (1), p. 126, Taf. v., fig. 7 (as *Panopæa*).

|| Weerth (1), p. 37, Taf. viii., fig. 7.

¶ F. A. Roemer (3), p. 330, pl. xli., figs. 20 21.

straight upper margin and little-curved lower margin. *P. baini* differs from this in being more equilateral and less produced and truncated posteriorly.

As regards the generic position of this shell, although the hinge-characters have not been described and I have been unable to investigate them, there is no reason to doubt that we are dealing with a typical *Pleuromya*, to which genus belong also, in all probability, the majority of the Neocomian forms to which the name *Panopæa* was formerly applied. There is no reason to suppose that the hinge-characters of *P. baini* differ essentially from those of *P. lutraria*, with which it is associated; and although it was the nature of the hinge that led Krauss to propose for the latter form the separate generic name *Anoplomya*, it appears plain from Terquem's \* detailed studies of the genus *Pleuromya* that the name proposed by Krauss must be regarded as a synonym—a view already adopted by Zittel.†

#### GENUS GONIOMYA J. L. R. Agassiz.

##### GONIOMYA sp.

This genus is represented by a single specimen of a small right valve. It is unfortunately imperfect, with a large part of the shell substance removed, and it is embedded in a very hard matrix which cannot be removed without further injury to the delicate shell.

*Description.*—The valve has little convexity and is posteriorly well produced. The umbo is rather pointed and prominent and shows a weak fold of the valve-surface extending for a short distance on its posterior side. The shell-substance is very thin and delicate. The ribbed ornaments of the surface are developed already close to the umbonal apex, where the anterior and posterior ribs are very delicate and closely spaced and are steeply inclined to form the V-pattern. The angle of the V is very acute, and the successive angles formed by the junction of the ribs of the two series are situated at first just below the umbonal apex, and then below one another on the flank on a slightly oblique line posteriorly inclined, so that the lowest angles of the sculpture are situated more backwardly than those above. The most backwardly situated ribs, which do not contribute to the angular ornamentation, are posteriorly inclined when traced down from their upper terminations. Posteriorly to the umbo there is a broad smooth area devoid of sculpture on the upper part of the valve, but this is not sharply demarcated from the flank.

\* Terquem (1); Terquem (2).

† Zittel (5), p. 125.



The anterior ribs are narrower and perhaps rather more prominent than the posterior ribs. Delicate and fairly regular lines of growth cross the surface of ribs and interspaces alike. The surface of the shell, where well preserved, is seen to be covered by very numerous and delicate, radially disposed lines of minute granules.

*Dimensions.*—The anterior part of the specimen is hidden in the matrix, but to judge from the course taken by the anterior growth-lines, the length of the valve may be fairly accurately estimated as 22 mm. The umbo is situated at about one-third of the total length from the anterior extremity, assuming that the above length-measurement is correct. The height of the valve at the umbonal region is 13 mm. The height of the siphonal border is 8 mm.

*Occurrence.*—Collected by Mr. Rogers from the highest beds in the kloof behind Colchester, Sunday's River Valley (489g).

*Remarks.*—This is the first specimen of *Goniomya* recorded from the Uitenhage Series. The condition of the single valve available for comparison scarcely justifies a specific determination, and the question of relationships cannot be usefully discussed without better material for study but the specimen probably represents a new species.

It is interesting to find the genus *Goniomya* represented here, in strata which yield the peculiar *Trigonia* of the group of *T. vau* which so strongly simulate the genus *Goniomya* both in the arrangement of the costate ornaments and in the general habit. Though the specimen above described at once recalls these *Trigonia*, it may be readily distinguished from them by the very thin shell-wall and the presence of surface granulation, as well as by the details of ornamentation. In *Trigonia vau* Sharpe and its allies, the neanic stage is ornamented by concentric ribs passing across the flank and area, and the inclination of the ribs with resulting angular pattern is not produced until the early adult stage. In this *Goniomya*, the costæ formed an anterior and a posterior series, steeply inclined, already in the neanic stage, at a very much shorter distance from the umbonal apex than in the *Trigonia* mentioned.

#### GENUS THRACIA W. E. Leach.

##### THRACIA sp.

##### Plate VIII., fig. 5.

A single specimen, which must be ascribed to this genus, is scarcely so well preserved or so strongly characterised as to allow

of a thorough comparison with known forms, or to warrant the use of a new specific name. The posterior end is slightly broken away so that the exact outline of the shell here cannot be clearly seen. The length is considerably greater than the height; the valves are of a compressed form, most convex in the uppermost third, more flattened below. The umbones are little conspicuous and are directed very slightly backwardly; they are situated just posteriorly to the middle of the shell. The upper margin slopes down very gently in front of the umbo, with an almost straight profile which passes into the evenly convex outline of the frontal margin. The posterior compressed area is well defined, especially in the neighbourhood of the umbo.

*Dimensions.*—

Length .....	40 mm.
Height, measured from the umbo.....	29 „
Depth of one valve .....	8 „

*Occurrence.*—In the railway cutting between milestones 24 $\frac{1}{2}$ –24 $\frac{3}{4}$  on the line between Uitenhage and Graaff-Reinet, about three miles from Uitenhage (331).

*Remarks.*—Comparison with English specimens of *Thracia philipsi* Roem.,\* from the Speeton Clay, shows that these differ widely from the shell before us by their much more inflated and prominent umbonal region and more steeply sloping antero-superior margin. In general form and outline the African shell shows close similarity to *Thracia subtruncata* Meek, from the Cretaceous strata of Sucia Islands (British Columbia).† The outline also somewhat nearly resembles that of *Thracia gracilis* Meek and Hayden,‡ from Cretaceous sandstone at the mouth of the Judith River (on the Missouri), but the latter is rather more elongated posteriorly.

Another shell which may be brought into close comparison occurs in the Aptian of Spain (Obon and Utrillas) and was described by Coquand§ as *Periploma lorieri*. To judge by Coquand's figure, this differs from the Uitenhage form by the steeper inclination of the carinal ridge and the more nearly parallel direction of the upper and lower margins anteriorly to the umbo.

\* *Mya depressa* Phillips, (1), Tab. 2, fig. 8 (*non* Sow.); *Thracia philipsi* F. A. Roemer, (2), p. 74, Taf. 10, fig. 1 (1841).

† Whiteaves (2), p. 140, pl. 17, fig. 7.

‡ Meek (2), p. 224, pl. 39, fig. 6.

§ Coquand (1), p. 100, pl. ix., figs. 5, 6.

*Thracia robinaldina* (d'Orbigny)\* is distinguished by its more oblong and less ovate outline, and its more conspicuous umbones. The African shell compares again more closely with the figure of a specimen from the Lower Cretaceous (Rolling Downs Formation) of Queensland, ascribed by Etheridge with some doubt to *Thracia primula* Hudleston, and figured under the generic name *Corimya*.† Less similarity is shown to the specimen originally named *Thracia primula*,‡ preserved in the British Museum (Natural History); this has greater relative height anteriorly to the umbo, a more curved inferior margin, more strongly compressed valves, a less inflated umbonal region, and less definitely developed posterior carination.

### GENUS GASTROCHÆNA L. Spengler.

#### GASTROCHÆNA DOMINICALIS Sharpe.

1856. *Gastrochæna dominicalis* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 198, pl. xxiii., fig. 4.

Sharpe described under this name a shell which had bored into a fragment of wood,§ found on the Sunday's River "near Enon." He also mentions the occurrence of *Gastrochæna* boring into fragments of wood and *Trigonia*-shell, also from the Sunday's River.

Fragments of fossil wood bored by *Gastrochæna* were collected by Messrs. Rogers and Schwarz from an oyster bed at the base of the cliff below the old school-house at Dunbrodie, Sunday's River (336). The shells are concealed within the short calcareous tubes which line their cavities, and some of these crypts measure about 6 mm. in length. There is no reason to doubt that these specimens represent the same form as that described by Sharpe. This shell was also found boring into lignite in strata of the "Wood Bed" series of the Bezuidenhout's River below Blue Cliff station.

\* d'Orbigny (3), p. 380, pl. 372, figs. 1, 2 (1845).

† Jack and Etheridge (1), p. 481, pl. 28, fig. 11.

‡ Hudleston (1), p. 245, pl. ix., fig. 7.

§ Sharpe spoke of this fragment as "bone," but this was corrected on p. 228 of Sharpe's paper and by Prof. T. Rupert Jones in an editorial footnote to Tate's paper in 1867, Tate (1), p. 155.



## CLASS GASTEROPODA.

## GENUS PATELLA Linnæus.

## PATELLA CAPERATA Tate.

1867. *Patella caperata* R. Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 152, pl. vii., fig. 1.

*Occurrence*.—A single specimen, on *Exogyra imbricata* Krauss, from the collection of the South African Museum, was obtained at Coega. Tate's figured specimen, in the collection of the Geological Society (No. 11,003), is labelled "Prince Alfred's Rest" (Sunday's River).

*Remarks*.—The specimen from Coega is more strongly elevated in form than Tate's original type. The apex in both is excentric in position, and as a result of this, the outline from the apex to the margin on the shorter side of the shell falls more steeply than that on the opposite side. Annular markings and growth-lines are more marked on Tate's specimen, because its surface has suffered less from weathering than that of the other individual.

The figured type of this species measures 28 mm. in longest diameter at the base, and the measurement at right angles to this, across the shortest diameter, is 22 mm. The height is 10 mm. The true dimensions of the Coega specimen cannot be measured satisfactorily because the shell has so suffered from weathering that its original margins are not preserved. There are indications that a firmly established station had been taken up, on the *Exogyra*. In one place, on the surface of the *Exogyra*, in the position which the serrated margin of the *Patella* formerly occupied, there are indentations which correspond with the terminations of the costæ on the *Patella*.

## GENUS PLEUROTOMARIA J. L. M. Defrance.

## PLEUROTOMARIA sp.

*Description*.—A large, ill-preserved and much-weathered specimen consists of at least five whorls. The body-whorl is flattened on its under side and its outer margin is obtusely angular; the surface of the whorl above this margin is very slightly convex. The suture falls at the bluntly angular margin of the whorls, so that the general figure of the shell in profile is that of a cone with little excavation at the sutural depressions and inconspicuous convexity of the outline

between these. The mouth aperture is of transversely oval form. The surface is so far weathered that no sculpture can be seen except on the base, where traces of numerous raised longitudinal (spiral) ornamenting ridges, crossed by ridges of growth, may be detected. The spiral angle is about  $85^{\circ}$ .

*Dimensions.*—

Height.....	90 mm.
Greatest width of base.....	100 „
Height of aperture .....	44 „
Approximate breadth of aperture .....	55 „

*Occurrence.*—Collected by Miss Wilman at Coega.

*Remarks.*—This single specimen is the first representative of its genus yielded by the Uitenhage beds, and it is a matter for regret that the preservation is so indifferent that a more precise description of characters is impossible. We must await the addition of further material before the nature of the sculpture can be ascertained and the nearer relationships made clearer; in the meantime it would be unjustifiable to propose a specific name. In general figure the shell is not unlike *Pleurotomaria* (*Leptomaria*) *tithonia* Zittel,\* but the spiral angle is rather wider than in that form, and if viewed in aperture-aspect it is seen that the whorl is deeper in section in the Uitenhage shell, and the mouth much less transversely elongated.

The form of the whorls is not unlike that of *Pleurotomaria tardensis* Stanton,† from the Belgrano beds (Lower Cretaceous) of Patagonia, which is also similar by reason of its large dimensions; but in the Coega specimen the outer margin of the body-whorl is less broadly rounded and the spiral angle is rather smaller.

GENUS TURBO Linnæus.

TURBO ATHERSTONI Sharpe.

Plate VIII., figs. 6, 6a, 7, 7a, 7b.

1856. *Turbo atherstoni* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 200, pl. xxviii., figs. 15, 16.

1856. *Turbo baini* D. Sharpe, *Ibid.*, p. 200, pl. xxviii., figs. 17, 18.

*Supplementary Descriptive Note.*—The shell consists of about six whorls, the first four of which have a smooth, flat, or very slightly concave upper surface, sloping down very gently from the spiral suture. The outer side of the whorl is truncated, with a sharp and

\* Zittel (4), p. 337, Taf. 50, figs. 5, 6.

† Stanton (3), p. 29, pl. vii., figs. 1, 2.

prominently projecting longitudinal (spiral) keel limiting the truncated band above, and also a similar one below. Under the lower marginal keel the surface of the whorl is gently convex in profile and slopes rapidly in. Just below the lower marginal keel there is a narrow, deep spiral sulcus bounded below by a delicate thread-like longitudinal keel. Below this there are four weaker raised spiral lines which are already developed in the third whorl, if not before. Until the fourth whorl is reached, the slightly concave outer band between the prominent marginal keels is smooth, but before this whorl is completed, in some individuals at its commencement, a weaker central keel appears.

The spiral angle varies somewhat, and averages about 70°. The last two whorls expand rapidly. The spiral suture is situated on the lower marginal keel of the whorls. The mouth has an angular outer lip, corresponding with the form of the whorls. The outer margin of the aperture is thin and sharp; under the columella the margin is slightly thickened.

*Dimensions.*—

{ Height of a specimen with four complete whorls	5 mm.
{ Diameter of the fourth whorl.....	4 „
{ Height of a specimen with five (or six ?) whorls	14 „
{ Diameter of the body-whorl.....	9 „

*Occurrence.*—Found in the cliff below the old school-house at Dunbrodie on the Sunday's River (351), where it is abundant. Specimens in the collection of the Geological Society of London are from "the lowest strata of the Zwartkop crag," and "greenish grit with *Ostrea* from Sunday River," as recorded by Sharpe. This form was obtained by Mr. Rogers in 1905 in a cliff W. 20 S. from Comley's house, right bank of Sunday's River (95h).

*Remarks.*—It is clear from a careful examination of the specimens in the collection of the Geological Society, together with the new materials supplied to me, that Sharpe was in error when he separated the shells described by him as *Turbo atherstoni* and *T. baini*. The differences which caused him to make the separation are in reality due to changes in the nature of the ornamentation during successive stages of growth; but the specimens at his disposal were very small and the materials so comparatively unsatisfactory that the mistake is not surprising. All specimens having the two marginal keels only, and consequently agreeing with the type of *T. atherstoni*, are very small individuals which have not reached the stage in which, by the intercalation of a central marginal keel and the more prominent development of the spiral ornaments on the lower part of the whorl,



the features of *T. baini* are exhibited. The change in characters is found to be very constant, although some slight variation may be shown as regards the exact period, in relation to the precise number of whorls developed, when the additional keel makes its appearance. In this connection also, differences of preservation prove very deceptive. As the adult stage becomes completed, it is noticeable how relatively rapidly, by the greater expansion of the whorls, the shell gains in length when compared with the proportional dimensions of the young individual.

This well-characterised form seems to resemble very closely *Turbo reedi* W. Keeping,\* from the Lower Cretaceous of England, and may be more aptly compared with this than with any other European shell with which I am acquainted. The type of ornamentation is essentially similar as regards major features, and while Keeping gave no account of the variation of sculptural characters when traced through successive stages, it seems probable that the central marginal keel became added between the two prominent keels during the course of individual growth, just as in *T. atherstoni*. The principal points by which the English shell differs, are seen in the greater number of spiral ribs on the lower part of the body-whorl and in the very delicate spiral striation and resulting granulation of the surface.

A somewhat analogous type of ornamentation is exhibited by a shell from the Upper Neocomian of Utrillas (Teruel), described as a *Trochus*, under the name *T. maestrei*, by de Verneuil and Lorière.† This, however, shows only two marginal spiral keels, while the base of the body-whorl is ornamented by several strong, well-spaced keels. Further points of distinction are the fine spiral lines which ornament the whorls, and the wider spiral angle.

A form which perhaps merits mention by way of comparison occurs in the Upper Jurassic *Aucella*-beds of Novaya Zemlya, and was ascribed by Tullberg to Münster's *Turbo capitaneus*.‡ This has ornaments similar to those of *T. atherstoni*, but there is less overlap of the whorls, the upper and lower marginal keels are less prominent and of similar strength to the central one, and the outline of the whorl is more rounded and less angular. There are apparently other differences, so far as it is possible to make comparison with the figure of the relatively large specimen figured by Tullberg.

\* Keeping (1), p. 97, pl. iii., fig. 13.

† de Verneuil and Lorière (1), p. 23, pl. ii., fig. 9.

‡ Tullberg (1), p. 9, pl. ii., fig. 1.

There is much closer resemblance, again, to *Turbo bitropistus* Ascher, from the Grodischter Schichten (of Hauterivian age) in Silesia.\* This, however, has a relatively narrower band between the two sharp marginal keels, and moreover, the surface of the shell is ornamented with numerous and delicate spiral lines.

TURBO ROGERSI sp. nov.

Plate VIII., figs. 8, 8a, 8b.

*Description.*—The shell consists of six whorls, possibly more. The whorls are flattened above, and the upper surface slopes very gently away from the spiral suture, terminating abruptly at a prominent marginal keel which marks the upper limit of the outer truncated face of the whorl. This truncated portion is straight in profile in the earlier whorls, but becomes gently but distinctly convex in the fourth or fifth whorls; it is bounded below by a prominent marginal spiral keel similar to the one above. Already in the third whorl, a central spiral keel makes its appearance, and this soon grows in strength, so that in the fourth whorl it is almost, if not quite, as prominent as the two pre-existing marginal keels, and subsequently it remains quite as conspicuous as these. At the completion of the fourth whorl, or perhaps a little before this, two additional well-marked, thread-like, raised linear ornaments become intercalated, one above and one below the central marginal keel. The lower part of the body-whorl shows a rounded, convex surface ornamented by about five delicate spiral keels, of which the uppermost is the strongest and is separated by a narrow sulcus from the lowest marginal keel.

The spiral angle is about  $75^{\circ}$ . The overlap of the whorls is such that the suture coincides with the lowest keel of the marginal area. In the earlier whorls the outwardly truncated form of the whorls gives a step-like profile with vertical outer face; in the later growth-stages (about the fifth whorl) the upper surface of the whorls becomes a little more convex and less abruptly demarcated from the marginal face, while the latter becomes more convex and merges gradually into the lower part of the whorl, so that the marginal truncation becomes successively obscure and lost and the whorl attains an aspect of even convexity. The mouth is then almost circular in outline, with thin outer lip not showing angularity of form. In the fifth whorl an indistinct and weakly developed sulcation appears on the upper surface of the whorl, immediately above the upper marginal keel and running parallel to it.

\* Ascher (1), p. 139 [5], pl. xii. [i.], figs. 1a-1c.

*Dimensions.*—

Height of specimen with five whorls ... 11 mm.

Diameter of the fifth whorl ..... 7 ,,

*Occurrence.*—In the cliff below the old school-house at Dunbrodie, on the right bank of Sunday's River (282).

*Remarks.*—This shell, represented in the collection by only two specimens, appears to be so closely related to *Turbo atherstoni* that at first I felt some hesitation in definitely separating it. A careful comparison with the specimens of *T. atherstoni* from Dunbrodie and those in the museum of the Geological Society shows, however, that it possesses distinctive characters which appear in no specimen of *T. atherstoni* that I have examined; the points of difference are as follows. In *T. atherstoni* the upper and lower marginal keels are very prominent and the outer area of the whorl concave in profile; the marginal keels in *T. rogersi* are less pronounced and the outer truncated area flat and vertical in profile in the earlier whorls. The central keel of *T. rogersi* makes its appearance much earlier and gains in strength so that it rapidly becomes as prominent as the two original peripheral keels; this equality is not attained in *T. atherstoni*. In *T. rogersi* two additional raised ornamenting lines appear on the peripheral area, while larger specimens of *T. atherstoni*, illustrating a more advanced stage of growth, have shown no similar development. Another feature of distinction is seen in the manner in which the whorls of *T. rogersi* lose their angularity of form with advancing growth and present an even convexity of surface not seen in the largest specimens of *T. atherstoni*. It is impossible to speak with certainty of any differences in the spiral angle, but the comparison of additional specimens, when these are forthcoming, may possibly show that the angle of *T. rogersi* rather exceeds that of *T. atherstoni*.

A *Turbo* described by Zittel from the Stramberg beds under the name *Turbo eryx* d'Orb., var. *major*\* is of similar type to *T. rogersi*, but differs in the more expanded form and wider spiral angle, and in the details of the spiral linear ornaments.

TURBO MINUTULUS sp. nov.

Plate VIII., figs. 9, 9a, 9b.

*Description.*—The shell consists of at least four whorls, and these are flattened above and sloping gently away from the suture, but vertically truncated at the periphery. The truncated marginal band

\* Zittel (4), p. 321, pl. xlvi., fig. 10.



is bounded above and below by a prominent longitudinal (spiral) keel; these two principal keels are of equal strength, and while the lower one is smooth (or nearly so), the upper one is bluntly nodular. Each of the rounded nodes of this keel is prolonged in wedge shape downwards into the marginal band, but the apices of the wedges die out before they reach the lower keel. At the end of the fourth whorl the wedge-like ornaments appear to be losing the well-defined character they possessed at the beginning of this whorl and before, while early in the fourth whorl an intermediate (central) peripheral keel makes its appearance, though it is less strongly developed than the two pre-existing marginal keels.

Below the marginal band the surface of the body-whorl has an evenly rounded outline; it is ornamented by three prominent spiral keels, one situated near the lower marginal keel and almost as strongly developed as this, the other two, rather weaker, below and in close proximity to one another. The spiral angle is about  $70^{\circ}$ . The spiral suture is immediately under the lower marginal keel. The mouth aperture has equal breadth and height. The outer lip is sharp and thin and slightly angular, in accordance with the form of the whorl. The inner lip is slightly thickened.

*Dimensions.*—

Height of specimen with four complete whorls	8 mm.
Greatest diameter of the last whorl.....	6 „
Height of aperture.....	4 „

*Occurrence.*—Cliff below the old school-house at Dunbrodie, on the right bank of Sunday's River (305, 351).

*Remarks.*—This form, though apparently a near ally of *Turbo atherstoni* and *T. rogersi*, is readily separable from these by the regular nodose ornaments on the upper marginal keel and peripheral zone below this, as well as by the stronger development and smaller number of the spiral keels on the under surface of the whorl, below the lower marginal keel. It seems probable that this shell would attain dimensions as large as those reached by *T. atherstoni*, and the appearance of a central marginal keel in the last whorl of the largest individual examined very strongly recalls the increase of the spiral ornaments in the associated forms mentioned.

TURBO sp.

An imperfect specimen, consisting of a body-whorl deprived of the spire, may be provisionally referred to this genus. The greatest breadth across the base is 8 mm., and the diameter of the mouth aperture which is nearly circular, measures 4 mm. The surface is

ornamented by rounded, shallow spiral grooves, and blunt spiral ridges having little prominence. These ornaments are so disposed that above the peripheral area a weakly marked ridge forms the outer limit of a narrow shoulder which is without spiral sculpture, while on the lower part of the peripheral area is a spiral groove, slightly broader than the three remaining grooves which lie below it. The surface is crossed transversely by numerous and well-marked ridges and furrows of growth, which are so regularly developed as almost to appear to constitute part of the sculpture.

*Occurrence.*—This was found, in association with the three forms previously described, in the cliff below the old school-house at Dunbrodie, Sunday's River (351).

*Remarks.*—This imperfectly preserved specimen is quite distinct from the other forms assigned to the genus *Turbo*, described above, but it will be well to await the collection of further material before applying a specific name. It can hardly even be said that the generic position is established beyond doubt. Although the rounded form of the whorl and the impressed spiral grooves might suggest at first sight that we are dealing with a fragment of an immature *Neritopsis ? turbinata* Sharpe,\* a comparison with Sharpe's specimens shows that this is not the case. The spiral ornaments lack the regularity, and the grooves are broader, less sharply incised and less regularly spaced than those of Sharpe's type. A complete comparison, it is true, is difficult, since the examples of *Neritopsis ? turbinata* preserved in the Geological Society's museum are all much larger than the fragmentary specimen here described, and the involution of Sharpe's shell is such that it is not possible to make satisfactory comparison at the same stage of growth; but the observable differences in the ornamentation are in themselves sufficiently significant.

Considerable resemblance is shown to a shell from the Neocomian of German East Africa described by G. Müller as *Delphinula africana*,† such similarity, in fact, as to suggest that we are dealing with a closely allied form. The shape and proportions of the body-whorl appear alike, and in each case there is the strong spiral groove on the lower part of the peripheral area. In the figure of *Delphinula africana* a spiral keel is seen, situated between this groove and the keel which defines the shoulder above. In the Dunbrodie specimen, which is of smaller dimensions than Müller's type, the beginnings of a similar keel, though weakly developed, are becoming apparent in the most advanced portion of the whorl. As regards other charac-

\* Sharpe (1), p. 198, pl. xxiii., fig. 5.

† G. Müller (1), p. 557, Taf. xix., fig. 11.



ters, it is not easy to make a detailed comparison, and it must suffice to have drawn attention to the apparently close resemblance between these shells. In his employment of the generic name *Delphinula* for forms such as these, Müller follows the usage of Stoliczka. Fischer has restricted the use of the name to living types, but it has been applied to certain *Turbo*-like shells of Jurassic and Cretaceous age by several leading authorities.\* In the case of the single specimen here dealt with, while it may be considered most expedient in the meantime to use the name *Turbo* as one of convenience, it appears not improbable that better preserved material may eventually show that a separation is necessary.

In the form of the whorl and the ornamentation great similarity is also shown to the figure of a specimen from the Aptian of Sainte-Croix, identified by Pictet and Campiche, perhaps wrongly, with *Turbo munitus* Forbes.† The African specimen is much smaller than this Swiss individual, but so far as a comparison with the figure is possible, the general agreement is very close. The specimen depicted by Pictet and Campiche in fig. 1 of the same plate has a taller spire and less expanded whorls than the original of fig. 3, and agrees much more closely with the typical *T. munitus* from the English Lower Greensand, and correspondingly less closely with this specimen from South Africa, apart from the differences in the ornamentation.

#### GENUS NATICA Lamarck.

##### NATICA UITENHAGENSIS sp. nov.

Plate VIII., figs. 11, 11a; ? figs. 10, 10a.

*Description.*—The shell consists of at least five whorls. The spire is very short, the body-whorl overlapping rather more than one-half of the preceding whorl and expanding relatively rapidly; the body-whorl occupies rather more than two-thirds of the whole height of the shell. The spiral suture is somewhat deeply impressed though not definitely channelled; the upper part of each whorl, adjacent to the suture, is slightly flattened to form a narrow rounded ledge, as seen in profile, the outer limit of which is not sharply defined, but forms a curved outline passing down into the rather flattened upper half of the whorl. This flattening of the whorl above the middle zone is most marked in the body-whorl of a well-grown individual, and even a slight depression of the surface here may be developed

\* See remarks by Hudleston and Wilson (1), p. 20; also Stoliczka (1), p. 368 (1868).

† Pictet and Campiche (1), 2<sup>e</sup> Partie, p. 480, pl. lxxxiv., figs. 3a-3c (1863).



during the fifth whorl. At the middle zone, and below, the whorl is evenly convex in outline.

The shell-wall is thick. The surface of the whorls is marked by numerous distinct, transverse growth-lines, which, however, do not form an obtrusive feature. The spiral angle is about  $90^\circ$ . The inner lip of the aperture is considerably thickened and forms a raised callus which bounds a well-impressed though closed umbilical slit. Just below this, and adjacent to the inner lip, the surface of the whorl presents a narrow, slightly flattened space. The height of the aperture is much greater than the breadth.

<i>Dimensions.</i> —	(1)	(2)
Height of shell .....	15	30 mm.
Height of body-whorl at the aperture	11	24 „
Greatest width at aperture .....	8	12 „

*Occurrence.*—Two well-preserved specimens in the collection of the Geological Society of London are labelled “Zwartkop, Dr. Atherstone, 1876.” A specimen from the railway cutting between milestones  $24\frac{1}{2}$ – $24\frac{3}{4}$  on the railway from Uitenhage to Graaff-Reinet, about three miles from Uitenhage (350), is referred with some doubt to the same species.

*Remarks.*—The specimen from the railway cutting (350) may perhaps be identical with Atherstone's two individuals, upon which this species is founded. It differs from them by its rather lower spire and slightly wider spiral angle, and by the more complete overlapping of the whorls. These differences may, however, be due to individual variation.

*Natica atherstoni* Sharpe,\* another Uitenhage shell, is distinguished by its much more slender and elongated figure and narrow apical angle ( $75^\circ$ ).

Compared at similar dimensions, *Natica lævigata* (Desh.) Leym.,† a Lower Cretaceous form, has much less overlap of the whorls, and consequently a higher spire and narrower spiral angle. *N. dupini* (Desh.) Leym.,‡ on the other hand, has a shorter spire and wider spiral angle, with wider and more inflated whorls and less elongated mouth aperture. The shell figured by d'Orbigny as *N. dupini* § shows much greater similarity to *N. uitenhagensis*, but this too has a wider spiral angle and a broader aperture as well as a distinct umbilical opening.

\* Sharpe (1), p. 200, pl. xxviii., fig. 22.

† Leymerie (2), p. 13, pl. 16, fig. 10.

‡ Leymerie (2), p. 13, pl. 16, fig. 7.

§ d'Orbigny (2), p. 158, pl. 173, figs. 5, 6 (1843).

In form and outline and in the shape of the aperture great resemblance is shown to the shell from the Stramberg beds figured by Zittel\* as *Natica (Ampullina) elegans* Sow.; this differs, however, by the slightly less overlap of the whorls and by the thinner shell; the inner lip is considerably less thickened than in the African form. It seems doubtful whether the Stramberg shell is identical with the English Portland *Natica* to which Sowerby gave the name *N. elegans*, and although Sowerby's figure † much resembles fig. 23a in plate 45 of Zittel's work, yet typical specimens of the Portland shell show a higher spire. *Natica uitenhagensis* is well distinguished from the English *N. elegans* by the much thicker shell and the lower spire. The shells from the "Portlandien supérieur" of Boulogne, ascribed to *Natica elegans* Sow. by de Loriol and Pellat,‡ whose determination was accepted by Hudleston and Wilson,§ are also slightly higher in the spire, and the aperture is broader and more rounded below.

The form described by Stanton as *Lunatia constricta*, from the Belgrano beds of Patagonia,|| shows great similarity to *N. uitenhagensis*, but differs apparently by the more strongly impressed sutures, the slightly less overlap of the whorls, and by the marked transverse furrows.

NATICA ROGERSI sp. nov.

Plate VIII., figs. 12, 12a, 13, 13a.

*Description.*—The shell is small, and consists of four whorls in the specimens examined. The body-whorl overlaps a little less than one-half of the preceding whorl, and occupies about two-thirds of the whole height of the shell. The spiral suture is well impressed or slightly channelled. The whorl-surface traced downwards from the suture presents an evenly convex surface.

The shell-wall is rather thick. The surface is marked by numerous transverse lines of growth and there is also a tendency to produce coarser, rounded, transverse ridges and furrows. The spiral angle is about 90°. The mouth aperture is broadly rounded below and narrowed and somewhat pointed above. The height of the aperture does not greatly exceed the breadth. The outer lip is sharp. Below, the margin of the aperture is thickened. On the inner side

\* Zittel (4), p. 289, Taf. 45, fig. 23.

† J. de C. Sowerby (2), p. 347, pl. xxiii., fig. 3.

‡ de Loriol and Pellat (1), p. 27, pl. iii., figs. 13–15.

§ Hudleston and Wilson (1), p. 81.

|| Stanton (3), p. 31, pl. vi., figs. 10, 11.

of the aperture is a well-developed callus. There is a slightly developed, short, closed umbilical slit.

*Dimensions.*—

	(1)	(2)	(3)
Height of the shell .....	11	12	13 mm.
Height of the body-whorl at the aperture	8	8	9 „
Greatest width of aperture .....	6	5.5	6 „

*Occurrence.*—Found by Mr. Rogers in the cliff on Buck Kraal, Sunday's River (136h).

*Remarks.*—This form is distinguished from small specimens of *Natica uitenhagensis* sp. nov. by the rather more expanded and less elevated figure of the shell, and the broader and more rounded form of the aperture. A specimen from the neighbourhood of Uitenhage (350), ascribed above with some doubt to *N. uitenhagensis*, is comparable in point of size with individuals of *N. rogersi*. It differs from these by its broader apical angle, shorter spire, narrower and more elevated figure, and relatively higher body-whorl and aperture.

NATICA? MIRIFICA sp. nov.

Plate VIII., figs. 14, 14a.

*Description.*—The shell consists of at least six whorls, and has a somewhat elongated turbinate outline with the body-whorl well produced and narrowed below. The body-whorl overlaps about half the preceding whorl, and occupies rather less than two-thirds of the total height of the shell. The spiral suture is well impressed, and below it the whorl-surface bulges out in the form of a convex spiral fold. Immediately below this rounded swelling of the whorl-surface is a depression of the surface forming a concave spiral band. This impressed zone is less well developed in the earlier whorls, more pronounced in character in the later ones. At the middle zone of the whorl the surface is again convex, and below this the whorl-surface slopes inwards with less marked convexity. The concave and convex zones in the upper half of the whorl merge into one another without the production of any angularities of the surface or of the outer lip of the aperture.

The shell-wall is moderately thick. The surface is smooth and only marked by transverse growth-lines. The spiral angle is about 70°. The aperture is elongated, its height being about twice as great as its maximum breadth. It is angular at its upper extremity and has a narrowed, rounded outline below. The inner lip is thickened and a callus is developed. There is a short, narrow, but closed umbilical slit.



*Dimensions.*—

Height of shell .....	27 mm.
Height of aperture .....	17 „
Greatest width of aperture .....	10 „

*Occurrence.*—Collected from the cliff on Buck Kraal, Sunday's River (137h). A fragment of a specimen, probably belonging to the same form, was obtained from the cliff W. 20 S. from Comley's house, right bank of Sunday's River.

*Remarks.*—This is a rather peculiar shell, and I am unable to state with certainty its true generic position. In spite of the elongated form, the relatively narrow spiral angle, the narrowed aperture, and the body-whorl produced and narrowed below, the characters of the shell appear on the whole to conform with those of naticoid type, while the close and smooth texture and lustrous appearance of the surface, when well preserved, seem to favour alliance with some division of the *Naticæ*. A striking feature of the shell is the longitudinal (spiral) depression of the surface of the whorls in their upper part. This character in less emphasised form is not unknown in *Natica*, though I am not aware that any described species exhibits it in such a marked degree as in the shells under discussion. The well-known *Natica bulbiformis* from the Gosau beds, figured by J. de C. Sowerby,\* has a distinct depression of the surface corresponding in position with the stronger sulcation in this African form. *N. bulbiformis* also has a relatively tall spire, but it is otherwise well distinguished by its more cylindrical whorls, the deep channelling at the suture and the more oblique direction of the mouth in relation to the long axis of the shell. *Natica angulata* from the same beds,† first figured by Sowerby, also shows in some degree a corresponding depression in the surface of the whorls.

There is a very close resemblance between *Natica? mirifica* and a Cretaceous gastropod from the steppes of Astrakhan, described and figured by B. Rehbinden under the generic name *Odostomopsis*.‡ The general form of the shell and the undulating outline of the whorl-surface is strikingly similar, but generic identity seems excluded by the absence of any fold on the columella in the African form. It may be questioned whether the specimens depicted in Rehbinden's figures 12 and 13 are identical with the originals of any of the other figures given by him under the same

\* In Sedgwick and Murchison (1), pl. xxxviii., fig. 13; see also Zekeli (1), p. 45, Taf. viii., fig. 2.

† Zekeli (1), p. 46, Taf. viii., fig. 4.

‡ Rehbinden (1), p. 139, pl. ii., figs. 12, 13.

specific name, and it is very doubtful whether they are correctly referred to *Odostomopsis abeihensis* (Blanck.), but it is certain that the Uitenhage form here ascribed with doubt to *Natica* cannot be brought into close comparison with Whitfield's genus.\*

GENUS ACTÆONINA A. d'Orbigny.

ACTÆONINA ATHERSTONI (Sharpe).

Plate VIII., figs. 15, 15a, 16, 16a, 16b.

1856. *Actæon atherstoni* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 200, pl. xxviii., fig. 19.

*Supplementary Descriptive Note.*—The shell consists of about six whorls, in the last of which there is a tendency to develop a steeply sloping and slightly convex shoulder below the suture, demarcated from the flattened central portion of the whorl by an ill-defined, blunt spiral ridge. The previous whorl also shows these characters, though in less marked degree, but the earlier-formed whorls have a more evenly rounded outline, most convex near the suture, more flattened below. The whorls are ornamented over their whole surface by numerous delicate, impressed, linear, spiral striæ which are crossed by more conspicuous furrows and rounded ridges of accretion, most noticeable in the last whorl. The spiral angle is about 45°.

*Dimensions.*—

Height of a specimen with six whorls.....	19 mm.
Greatest diameter of the last whorl.....	9 „
Height of the aperture .....	10 „
Greatest width of the aperture.....	4·5 „

*Occurrence.*—Collected at Grass Ridge, three miles east-north-east of Uitenhage (333), and from a clay-pit in the lower part of the Marine Beds on the left bank of the Zwartkop's River near Rawson Bridge (343); also at Dunbrodie, Sunday's River (283, 284). Specimens from the South African Museum are from the Sunday's River. The record of occurrence given by Sharpe was "the lowest strata of the Zwartkop crag." Mr. Rogers collected specimens of this form in 1905 at the bare slope W. 30 S. from the middle of Barkly Bridge, on the farm Olifant's Kop, Sunday's River (24h); from the highest beds in a kloof behind Colchester, Sunday's River (499g); and from a cliff W. 20 S. from Comley's house, right bank of Sunday's River (92h). From this last locality was also obtained a specimen (95h)

\* Whitfield (1), p. 425.

which may possibly belong to this species, though it possesses certain distinguishing characters which are noted below.

*Remarks.*—Sharpe's figured type, in the collection of the Geological Society of London, is an unsatisfactorily preserved immature specimen with the shell partially removed. The smallest example sent to me from South Africa measures 6.5 mm. in length, and is considerably larger than the figured type, but a careful comparison convinces me that these and the larger shells, one of which attains a length of 19 mm., represent the same form. All the specimens submitted to me have their whorls covered throughout with the delicate spiral striæ, and it was probably the imperfect preservation of his material which led Sharpe to believe that these markings are confined to the lower part. Relatively to the size of the whorls, the spiral ornamentation is strongest in youthful and early adult stages, weakest in the last whorl. A single specimen collected by Mr. Rogers (95h) differs from the majority of the individuals examined by its taller spire, narrower spiral angle and less inflated body-whorl: the degree of overlap in the whorls is also rather less, and the body-whorl occupies less of the total height of the shell (see plate viii., fig. 17). This may possibly represent a distinct species, but it bears so close a general resemblance to *A. atherstoni* that it is difficult to arrive at a decision on this point, especially as some variation is observable in the other individuals.

The examination of well-preserved adult specimens shows that this species possesses a mouth of oval form, rounded below, with sharp outer lip and a columella quite devoid of folds. It therefore falls within d'Orbigny's genus *Actæonina* as restricted by Meek,\* under which name it was correctly quoted by Messrs. Rogers and Schwarz in their report on the survey of 1900.

There is some resemblance between *Actæonina atherstoni* and the Belgian shells ascribed by Briart and Cornet† to the Blackdown species named *Phasianella striata* by J. de C. Sowerby, and described under d'Orbigny's name *Phasianella sowerbyi*.‡ This has a shorter spire than the African form, but to judge from the figures given by the Belgian authors, the slender outline of the shell and the shape of the mouth are very similar, although the two forms are perhaps not even generically identical, and the striæ are coarser in the Belgian shell. In another Blackdown species, described by Sowerby under the name *Phasianella formosa*,§ the shape of the

\* Meek (1), p. 91.      † Briart and Cornet (1), p. 35, pl. iii., figs. 20, 21.

‡ d'Orbigny (4), vol. ii., p. 152.

§ J. de C. Sowerby (2), p. 343, pl. xviii., fig. 14.



whorls and the mouth closely approaches that of *Actæonina atherstoni*, but the spire of the English shell is relatively shorter, and the spiral striæ are confined to the lower part of the whorls.

A specimen from the Upper Cretaceous beds of Umkwelane Hill, Natal, has been described as a variety of *Actæonina atherstoni* by R. Etheridge, jun. (var. *umkwelanensis*).<sup>\*</sup> To judge from the figure of this supposed variety, there is a general resemblance to *Actæonina atherstoni*, although the spiral striæ are depicted as of a coarser character than in the Uitenhage form. Mr. Etheridge's remarks on his new variety do not suffice to enable a satisfactory comparison to be made, but I am inclined to doubt the likelihood of near relationship between these forms.

*Actæonina haugi* Ascher, from the Grodischter Schichten,<sup>†</sup> the equivalent of the Hauterivian in Silesia, is of similar general type to *A. atherstoni*, and is ornamented over the whole surface of the whorls by minute spiral striæ. It is more slender and elongated, however, and more cylindrical in form, and has a narrower spiral angle and less convex whorls than *A. atherstoni*. The specimen numbered 95h, mentioned above, approaches closely to *A. haugi* in the form of the spire, but has a more convex and less cylindrical body-whorl.

#### GENUS LIMNÆA Lamarek.

##### LIMNÆA REMOTA sp. nov.

Plate VIII., figs. 18, 18a.

*Description of a Single Specimen.*—The specimen, which is imperfect at the apical end, consists of nearly four whorls, and is wound in the form of a tall spire, having a somewhat pupoid figure. The outline of each whorl slopes down very steeply from the spiral suture, giving the whorl a gently and evenly convex profile. The volutions are relatively high between the sutures. The body-whorl overlaps about one-third of the previous whorl, and occupies nearly one-half of the total height of the shell. The rather steeply inclined spiral suture is not deeply impressed.

The spiral angle is about 30°. The shell-wall is thin, and its outer surface is marked by numerous wrinkles and furrows of accretion. The mouth aperture is in the form of an acute angle above, and is of rounded oval outline below. Its height is about twice as great as

<sup>\*</sup> Etheridge (1), p. 87, pl. ii., fig. 38.

<sup>†</sup> Ascher (1), p. 152 [18], Taf. xii. [i.], fig. 12a-c.

its breadth. The outer lip is thin and the inner lip only furnished with a very thin callus-coating.

*Dimensions.*—

Height of shell .....	33 mm.
Height of body-whorl at the aperture ...	17 „
Greatest width of the aperture .....	8.5 „

*Occurrence.*—The specimen was collected by Mr. Rogers from the cliff on Buck Kraal, Sunday's River (138h).

*Remarks.*—This is the only fresh-water form included among the fossils found in the cliff-section on Buck Kraal, and it seems most probable that it represents a merely stray occurrence in marine strata, and does not indicate the presence of a fresh-water bed. The specimen may have become washed down into marine surroundings by flood-waters, but its fresh appearance suggests that it could not have been subjected for long to the action of currents before becoming embedded.

The resemblance shown by this specimen to *Limnæa longiscata* Brongn.,\* which occurs so abundantly in the Headon Beds of the Hampshire basin and in the Paris basin, is really very striking. Although selected specimens of *L. longiscata* may approach very closely in all characters to the form with which we are dealing, yet this may be well distinguished from most specimens of the Tertiary shell by its more slender and elongated figure. The spiral angle of *L. longiscata* is frequently wider, and the body-whorl is almost always more tumid than in *Limnæa remota*.

## CLASS CEPHALOPODA.

### GENUS PHYLLOCERAS E. Suess.

#### PHYLLOCERAS ROGERSI sp. nov.

Plate VIII., figs. 19, 19a-c.

*Description of a Single Specimen.*—The shell is very involute, with minute umbilicus. The umbilical wall is not abruptly marked off from the flank. The whorls have a laterally compressed form, and the flanks show a slightly convex surface. The height of the whorl, measured from the umbilical rim, is greater than the breadth seen in cross-section. The greatest breadth of the whorl-section occurs at

\* Edwards (1), p. 85, pl. xii., figs. 3a-h; Deshayes (1), p. 92, pl. xi., figs. 3, 4 (1825).

about the middle of the flank, and from here the whorl narrows very gradually towards the periphery, which forms a relatively broad, flattened arch.

The surface is ornamented with closely set, delicate, linear transverse ribs, which have a very slight forward inclination when traced from the umbilicus towards the periphery. On a portion of the last whorl which measures 9 mm. from the umbilical centre to the periphery, there are 12 ribs crowded into a space of 2 mm. at the middle of the flank. There are no constrictions.

The specimen is imperfect, and is wholly septate. The course of the lobe-line is relatively complex in its details. The siphonal (external) lobe is narrow and very deep, and the small siphonal saddle at its termination narrows somewhat abruptly to a sharply pointed summit. The siphonal lobe is as deep as the first lateral lobe.

*Dimensions.*—

Greatest diameter, if completed, about..... 30 mm.

Greatest breadth of the last whorl in cross-section 16 „

Height of the last whorl at the centre, in section... 13 „

*Occurrence.*—Found in the kloof behind Colchester, Sunday's River Valley, in the middle beds (3h).

*Remarks.*—This specimen, so far as I am aware, is the only representative of the genus *Phylloceras* which has been found in the Uitenhage Series. It is, unfortunately, not a complete individual; the body-chamber is absent, and a portion of the last whorl preserved is also broken away. The surface ornaments are only preserved in a few small patches on the early part of the last whorl, where the outer surface has escaped destruction. In the remaining portions of the surface which are exposed, sufficient of the shell substance is present to prevent the septal suture-line from being seen. It has, therefore, been necessary to etch away part of the shell with acid in order to obtain a view of the suture-line, but owing to the mode of preservation of the cast, the picture obtained is not so satisfactory or complete as might be desired.

It has been possible, however, to trace the course of the lobe-line so far as concerns the siphonal lobe, the first lateral saddle and the first lateral lobe. The most striking feature is the depth of the siphonal lobe, which touches a radius which is reached by the first lateral lobe. In other respects the lobe-line, so far as observed, very much resembles that given by d'Orbigny in the case of his *Ammonites picturatus*,\* from the Lower Neocomian of France; although both

\* d'Orbigny (1), p. 178, pl. liv., figs. 4-6 (1841).



suture-lines are so complex, the agreement, in fact, is remarkably close. *Phylloceras picturatum* has somewhat less inflated whorls than the African form, and its surface is said to be entirely smooth.

In the depth of the siphonal and first lateral lobes of the septal suture, there is agreement with *Phylloceras semisulcatum* (d'Orb.)\* but the suture of that form is much less complex in its details.

There is considerable similarity of form to a specimen from the Wernsdorfer Schichten (Barrémian of Silesia) described by Uhlig under the name *Phylloceras* cf. *guettardi* Rasp.† The whorl-section of this shows that the flanks converge slightly towards the periphery, which is narrowly arched. In the African specimen the flanks are not so markedly convergent, but are more nearly parallel, and they are perhaps a little less convex. The peripheral area is broader, and in the cross-section of the whorl a greater breadth is maintained up to the peripheral part. There are no noteworthy points of agreement in the course of the septal suture of these two forms. In the shell described by Uhlig, which is said to have a suture identical with that figured by d'Orbigny for *Phylloceras guettardi*,‡ the siphonal and first lateral lobes are of unequal length, and the suture is considerably less complex in its details.

The specimen here described appears to represent a new species, but it will be necessary at some future time to supplement the present imperfect account by additional notes, and by the illustration of the septal suture of a more favourably preserved individual.

## GENUS BOCHIANITES P. Lory.

### BOCHIANITES GLABER sp. nov.

Plate VIII., figs. 20, 21.

*Description.*—The shell has a delicately attenuated form, and increases very slowly in diameter. Near the delicately pointed posterior end the shell is cylindrical, but becomes slightly compressed laterally, with corresponding elliptical section, when traced towards the anterior end. The surface is devoid of ornamentation, and is marked by numerous minute lines of growth which show a slight anterior arching on the siphonal side, and when traced across the flank of the shell are directed somewhat posteriorly; they follow a straight course (or have an exceedingly gentle and broad

\* d'Orbigny (1), pl. liii., fig. 6 (1841).

† Uhlig (1), p. 182, Taf. iv., fig. 9.

‡ d'Orbigny (1), pl. liii., fig. 3 (1841).

anterior arching) when passing across the anti-siphonal side. In addition to these lines there are very faint and indistinct shallow depressions of the surface, of varying breadth, which follow a course similar to that of the growth-lines.

It has only been possible to follow completely the course of the septal line at an early stage of growth, where the shell has a diameter no greater than 2 mm., and, as might be anticipated, the suture is here of a comparatively simple character. While the main lobes and saddles have come to full development as regards their general course, the minor indentations of the suture have only in small degree made their appearance. The siphonal, anti-siphonal, and lateral lobes are narrow and deep, and have almost equal elongation. At this comparatively early stage the trifid character of the lateral lobe is already making its appearance. Both the siphonal and lateral saddles are divided into two limbs by a narrow and shallow subsidiary lobe. Each limb of the saddle is in turn divided by a shallow, pointed indentation. The lateral saddle is slightly broader than the siphonal saddle. The small secondary saddle at the base of the siphonal lobe is at this stage weakly developed and has a blunt summit.

*Dimensions.*—

Length of a specimen with body-chamber, but incomplete

at initial and anterior ends .....	50 mm.
Diameter at the posterior end .....	2 "
Greater diameter at the anterior end .....	5 "

*Occurrence.*—Found on the road below the railway cutting, one mile from Rawson Bridge on the main line, up side (277, 338). Crushed specimens obtained from the clay-pit on the left bank of Zwartkop's River near Rawson Bridge (278, 339, 344), referred by Messrs. Rogers and Schwarz with some doubt to *Baculites*, may probably represent the same form.

*Remarks.*—The adoption of the name *Bochianites*, proposed by P. Lory\* for *Baculites neocomiensis* d'Orb. and its allies, seems to be well justified when a comparison is made between the septal sutures of the forms to which the name is applied and those of the true *Baculites* as exemplified, for instance, by *B. baculoides* (Mant.) or *B. bohemicus* Fritsch and Schloenbach. Whether we are to regard

\* Lory (1), p. 133, footnote; Lory (2), p. 129, footnote. [I have not been able to consult the latter work quoted, but give the citation on the authority of von Koenen (2), p. 397, and G. Boehm (3), p. 26. The papers Lory (1) and Lory (2) have identical title and date of year, but I have not ascertained which was issued first; one is presumably a reprint of the other, except in pagination.]

*Bochianites* as a separate genus or as a sub-genus of *Baculites* might, perhaps, be considered doubtful, and on this point G. Boehm, who adopts the name,\* has refrained from expressing an opinion. Sarasin and Schöndelmayer ascribe a generic value to the name, and consider that a comparison of the septal sutures indicates that *Bochianites* and *Baculites* have originated separately;† the differences revealed by such a comparison are, in fact, so striking and so constant that with present knowledge it appears to be a reasonable and expedient course to regard these forms as generically distinct. In *Bochianites* there is a siphonal lobe, an anti-siphonal lobe, and on either side one main lateral lobe. These are relatively narrow and of almost equal depth. An important distinctive feature is the trifid termination of the lateral lobe. On either side there are two relatively broad saddles, each divided fairly symmetrically by a narrow subsidiary lobe. There are thus typically only four main lobes and four saddles, though in some forms (for example *B. undulatus* von Koenen) the lateral saddle is so deeply divided that it might be almost regarded as forming two saddles separated by a lobe less deep than the lateral lobe. To obtain the septal suture of *Baculites*, we must imagine the subsidiary lobe of the lateral saddle to be so deepened as to constitute an additional lateral lobe; at the same time the anti-siphonal lobe becomes very much less deepened, while the first lateral lobe should have a paired instead of a trifid termination. These relations are very well revealed by a comparison of the suture-line in *Bochianites neocomiensis*‡ and *Bochianites wateringi*§ with that in *Baculites baculoides*|| and *Baculites bohemicus*.¶

There can be no doubt that the Uitenhage specimens must be referred to *Bochianites*, as clearly indicated by the course of the lobe-line. One of the chief distinctive characters of the form here dealt with appears to be the absence of surface ornaments, and even allowing for imperfect preservation, it may be regarded as certain that the available material would have shown definite traces of ribbing if such had existed. Specimens from the clay-pit near Rawson Bridge, which I think may represent the same species, are much crushed, but the shell-substance is in great part preserved and retains its nacreous lustre. In these there is no trace of ribbing, and the shell appears to have been a smooth one.

\* G. Boehm (3), p. 26. † Sarasin and Schöndelmayer (1), p. 177.

‡ d'Orbigny (1), p. 560, pl. 138, fig. 4 (1842).

§ G. Boehm (3), p. 26, fig. 3. || d'Orbigny (1), p. 562, pl. 138, fig. 11 (1842).

¶ Jahn (1), pl. viii., fig. 7; Woods (1), p. 76, pl. ii., fig. 10.



A form with which it might seem possible to bring *Bochianites glaber* into close comparison is *B. oosteri* Sarasin and Schöndelmayer,\* from the Swiss Neocomian. This is also devoid of ornamentation so far as has been ascertained; but it appears to be well distinguished by the great breadth of the lateral saddle in relation to the siphonal saddle, and by the deeply divided form of the lateral saddle. This division is carried so far, indeed, that it may be said that two lateral saddles are developed. If *B. glaber* possessed in maturity a septal suture having the relations of lobes and saddles similar to those exhibited in *B. oosteri*, it would be right to expect that some signs of it would be evident even at an early stage. Traces of the suture of *B. glaber* where the shell has attained a diameter of 4 mm. are still of a very simple character, and show no promise of such sub-division at a later stage of growth as that which characterises the mature *B. oosteri*. Moreover, the septa of *B. glaber* are much more closely approximated than those of the Swiss shell, in which the length of the chambers is a special feature.

*Bochianites undulatus* von Koenen,† from the lower Aptian of North Germany, is well distinguished from *B. glaber* by the well-developed ornamentation and the deeply divided lateral saddle, as well as by other features.

*Baculites rotundus* Reuss,‡ from the Plänermergel of Bohemia, is also a smooth, slowly tapering form, but without particulars of the septal line it is impossible to make a close comparison. *B. rotundus* may be a true baculite, and Pictet has even suggested that its real position may be in the genus *Hamites*.

#### GENUS HOLCOSTEPHANUS M. Neumayr (*sensu stricto*).

The great majority of the ammonites included in the collections under examination belong to that section of the original genus *Holcostephanus* exemplified by d'Orbigny's *Ammonites astierianus*, the form which was regarded by Neumayr to be the best known typical species of his genus.§ To this species and some allied forms Pavlow gave the name *Astieria*, when recognising that the wide application of the name *Holcostephanus* was not in accordance with

\* Sarasin and Schöndelmayer (1), part 2, p. 179, pl. xxiv., figs. 3, 4, and text-figure 6.

† von Koenen (2), p. 398, pl. liii., figs. 11, 13, 14.

‡ Reuss (1), part i., p. 24, pl. vii., fig. 4 (1845).

§ Neumayr (1), p. 922.

the results and requirements of modern work, and that a division into a number of genera or sub-genera had become necessary.\* If we were to ascribe to the name *Holcostephanus* the broad signification allowed by Neumayr, Zittel, and others, it would certainly be convenient to use the name *Astieria* to denote one of several sub-genera, were this procedure not contrary to the recommendations of the International Zoological Congress.† It will be more correct, as Lemoine has pointed out, to restrict the name *Holcostephanus* to that portion of the genus, as originally conceived, which is typified by *H. astierianus*, and apply it in place of *Astieria*.‡

The separation of *Spiticeras* from Pavlow's *Astieria*, as proposed by V. Uhlig and F. Suess, appears to be a well-founded step in the recognition of further divisions within the broadly conceived genus *Holcostephanus*. *Holcostephanus*, sensu stricto (= *Astieria* Pavlow, emend. V. Uhlig and F. Suess) thus becomes a group having very narrow limits, and some division of opinion is likely to exist concerning the question of its generic or sub-generic value. This at present must remain a matter for individual judgment, and in view of our rapidly growing knowledge and the other causes which contribute to the present instability of ammonite-classification, it is a question of comparatively subordinate importance. For the purposes of the present work the name will be employed in a generic sense, as the equivalent of the restricted *Astieria* of Uhlig and F. Suess.

It is unfortunate that the specimens of *Holcostephanus* obtained from the rocks of the Uitenhage Series are usually in a state of preservation unfavourable for exhaustive study. Thus, in no case has it been possible to ascertain the true course of the lobe-line, while evidence regarding the form of the body-chamber and mouth aperture is likewise still scanty. We must also look to further collecting to furnish materials for a study of individual development in the various forms represented, and it is clear that there is much to be added in order to supplement the following imperfect account of this interesting assemblage. There can be no doubt, however, that the characters of shape and ornament displayed by the available specimens suffice to enable us to read aright the relationships of these forms, though perhaps not always with the precision that might be desired.

It may be pointed out that in the diagnosis of *Astieria* given in Uhlig's monograph on the Fauna of the Spiti Shales § a sentence

\* Pavlow and Lamplugh (1), pp. 471, 491 (113, 133 of authors' copy).

† Règles Internationales de la Nomenclature Zoologique adoptées par les Congrès Internationaux de Zoologie; articles 9, 25, 29. Paris, 1905.

‡ Lemoine (1), p. 181.

§ Uhlig (4), p. 86.

occurs which does not seem to express quite accurately the relations most frequently exhibited in the secondary ribbing. It is stated that, starting from the tubercles at the margin of the umbilical wall, there are groups of secondary ribs "which bifurcate higher up and admit of intercalary ribs." It would perhaps have been more correct to say that bifurcation of the secondary ribs on the flank (away from the tubercles) occurs rather as an exception than as a rule, since it is certainly either absent or very rare in the majority of known "*Astieria*." In typical specimens of *H. astierianus* (d'Orb.), as figured by d'Orbigny himself,\* no bifurcation in the costæ of the rib-bundles after they leave the tubercles is apparent, but the finely ribbed forms (d'Orbigny's plate 28, fig. 4), which have been named *H. sayni* by Kilian and *Astieria scissa* by Baumberger, show the division of the ribs here and there on the flank. In all the South African representatives of *Holcostephanus* the groups of secondary ribs proceed from the compressed umbilical tubercles and pass over the periphery to the tubercles of the other side without undergoing any division. It may be noted, however, that the ribs forming a group on one flank may become so disposed when traced to the opposite flank that they do not all reunite at one tubercle; thus, of three ribs departing from a tubercle on one side, two may unite again at a tubercle on the opposite side of the whorl, while one may either pass to an adjacent tubercle or may terminate in the space between two tubercles at the umbilical rim.

There is one other point in Uhlig's diagnosis of *Astieria* which seems to call for emendation. It is stated that the ornamentation "consists of a varying number of primary costæ which start from the suture, and at the passage from the umbilical wall into the sides swell up into tubercles." A specimen obtained by Messrs. Rogers and Schwarz near Uitenhage, and described below (*H. uitenhagensis* sp. nov.), is so characterised that it can only be ranged among the "*Astieria*"; but in this example the ornamentation commences with the marginal tubercles, and no primary umbilical costæ are developed in the last whorl. It seems therefore necessary to say that although primary umbilical ribs are present in the majority of the *Holcostephani*, yet they do not form an essential part of the sculpture in all growth-stages. It may be that in the specimen referred to, umbilical ribs were developed in the earlier growth-stages represented by the inner whorls, but these, owing to unfavourable preservation, unfortunately cannot be studied. In this specimen, which is of considerable size, the ultimate whorl probably represents a stage approaching, or in,

\* d'Orbigny (1), p. 115, pl. 28, fig. 1 (1840).



the final phase of individual growth, and it is only in this whorl that the umbilical wall has been satisfactorily exposed and freed from the matrix.

The predominance of *Holcostephani* in the cephalopod-fauna of the Uitenhage beds is no less striking than the manner in which certain of these lend themselves to close comparison with European forms. There is apparently near relationship to types well distributed in the Valanginian and Hauterivian of the European continent and more sparingly represented in England, and in this fact we may recognise the most reliable evidence for a correlation of the Uitenhage Marine Beds with European standards. It will be well, for the present, to regard with the greatest caution the apparently peculiar geographical distribution of *Holcostephanus*, since so little is yet known of any cephalopod-faunas, in tropical or sub-tropical latitudes, which may be brought into correlation with that of the Uitenhage Series. Some remarks on this subject have already been made in the previous section of this memoir.

I have to acknowledge my indebtedness to Mr. G. C. Crick for kindly assisting me to compare some of the specimens described below with representatives of *Holcostephanus* preserved in the British Museum (Natural History).

*HOLCOSTEPHANUS ATHERSTONI* (Sharpe).

1856. *Ammonites atherstoni* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 196, pl. xxiii., fig. 1.  
 1882. *Olcostephanus atherstoni* M. Neumayr, in E. Holub and M. Neumayr, Denkschr. d. k. Akad. Wiss., Math.-Nat. Cl., Band xli., p. 272.  
 1892. *Olcostephanus (Astieria) atherstoni* A. P. Pavlow (*partim*), in A. P. Pavlow and G. W. Lamplugh, Bull. Soc. Imp. Nat. Mosc., année 1891, Nouv. Sér., tome v., p. 495 (p. 137 of authors' copy). (Probably not pl. xvii., fig. 14.)

*Occurrence.*—Collected by Miss M. Wilman at Coega. A specimen from the South African Museum is probably from the Sunday's River. The type-specimen in the Geological Society's collection in London is from the Sunday's River (registered 10975). Messrs. Rogers and Schwarz have recorded this form from the Zwartkop's River valley in the neighbourhood of Uitenhage.\* Mr. Rogers has also noted its occurrence at several localities in the valleys of the Coega and Sunday's Rivers. †

\* Rogers and Schwarz (1), p. 9.

† Rogers (2).

*Remarks.*—Some characteristic points in *H. atherstoni* are the strong, backwardly directed umbilical ribs, the steep umbilical wall, the relatively narrow and profound umbilical cavity, and the considerable breadth and inflation of the whorls. The involution until the shell has attained large dimensions is such that the umbilical wall of a given whorl falls upon the umbilical tubercles of the previous whorl, wholly concealing the secondary ribbing. In the large type-specimen of *H. atherstoni*, measuring 140 mm. in greatest diameter, the last-formed whorl is beginning to show a little less involution, and its most advanced part leaves the tubercles of the previous whorl wholly exposed, and also the commencement of the rib-bundles of the flank.

It has been stated by several authors that *H. atherstoni* occurs in the Valanginian and Hauterivian of Europe, and since such an occurrence would be of high interest, both from a stratigraphical and palæontological point of view, I have taken some pains to test the value of these identifications. The result has been to convince me that none of the determinations can be upheld with certainty.

Pavlow considered *Holcostephanus psilostomus* Neum. and Uhlig,\* from the Neocomian of North Germany, to be identical with *H. atherstoni*, or at least that the two forms represent no more than varieties of a single species. Uhlig, on the other hand, believes this view to be erroneous,† and points out that *H. atherstoni* has an almost semicircular cross-section and greater breadth. There can be no doubt that, though closely comparable, these types are not identical. Another allied North German form, from the zone of *Hoplites radiatus* (Lower Hauterivian) has been described and figured by von Koenen‡ under the name *Astieria* aff. *psilostoma*. In this, the rate of increase in the breadth of the whorls is not so rapid as in *H. atherstoni*, and the ribbing is a little coarser. The pronounced development of constrictions is another distinguishing feature.

Another European form which bears considerable resemblance to *H. atherstoni* has been described by von Koenen as *Astieria convoluta*§ from the Lower Hauterivian of North Germany. This appears to have similarly inflated whorls and a narrow umbilicus, but the number of umbilical tubercles is fewer than in *H. atherstoni* at a comparable stage of growth, and the ribs are coarser and less numerous.

\* Neumayr and Uhlig (1), p. 149, Taf. xxxii., fig. 2.

† Uhlig (4), p. 132.

‡ von Koenen (2), p. 151, Taf. liv., fig. 2.

§ von Koenen (2), p. 146, Taf. xxxix., figs. 4a, 4b.

*Holcostephanus multiplicatus* Neum. and Uhlig (non Roemer) \* from the Upper Valanginian of North Germany, which has been renamed *Astieria ventricosa* by von Koenen, † approaches *H. atherstoni* in the fine character of the ribbing, but is well separated by the much higher whorl-section and the conspicuous development of constrictions, as well as by other characters.

Certain forms occurring in the south-east of France and in the Maritime Alps, ascribed by Kilian to *H. atherstoni*, ‡ seem to have been so named in the belief that *H. multiplicatus* Neum. and Uhlig (= *Astieria ventricosa* von Koenen) is identical with *H. atherstoni*. Baumberger has also spoken of the "Zone of *Holcostephanus multiplicatus* Neum. and Uhlig, non Römer = *H. atherstoni* Sharpe" in the Lower Hauterivian of the Swiss Jura. § Early in the present year, however, he has taken pains to show that the earlier identification of *H. multiplicatus* with *H. atherstoni* was erroneous. ||

When we come to discuss the correctness of Baumberger's view that a group of forms represented richly at the base of the Hauterivian (the so-called *Astieria* Zone) in the Swiss Jura is really inseparable from *Holcostephanus atherstoni*, the difficulty of forming a final judgment becomes very great. Baumberger discusses the question in great detail, ¶ and his conclusion is put forward judiciously and not with any claim to be the final word in the matter. Some, at least, of the specimens figured by Baumberger bear a strikingly close resemblance to *H. atherstoni*, and it appears safe to conclude that the relationship is a very close one. It appears possible that more than a single species is represented in the Swiss material brought together by Baumberger under Sharpe's specific name, but I am not in the position to form a definite judgment on this point. Of the larger specimens figured by Baumberger, which from their size are most fitly comparable with the large type-specimen from South Africa, that depicted in plate xxiv., fig. 2, seems to agree most closely in the fineness of the ribbing. The specimen shown in plate xxiii., fig. 1a, exhibits more clearly the characters of the umbilical part of the shell, and allowing that this is an internal cast, the figure might well have been drawn from a South African specimen. The apertural view (fig. 1b), however, unless the peripheral part is much crushed down, shows that

\* Neumayr and Uhlig (1), p. 150, Taf. xxxiii., fig. 2.

† von Koenen (2), p. 144.

‡ Kilian (1), pp. 716, 726, 735; Kilian (4), p. 865; Kilian and Leenhardt (1), pp. 973, 979, 981; Matte (1), p. 151.

§ Baumberger (1), 2<sup>er</sup> Theil, p. 3.

|| Baumberger (1), 4<sup>er</sup> Theil, p. 40.

¶ Baumberger (1), 4<sup>er</sup> Theil, pp. 39-47 (*Astieria atherstoni*).



the whorl is not nearly so highly arched in section as in *H. atherstoni*. In this character, the specimen shown by Baumberger in his text-figure 115 agrees more closely. The whorl-section shown in fig. 114, on the other hand, is not quite so highly arched in proportion, and seems to agree better with that shown by the South African specimens described below as *H. cf. atherstoni*. As regards the development of constrictions, these, if truly developed, are so inconspicuous in South African specimens that they can scarcely be detected, and they never form a feature like that shown in Baumberger's text-figure 116.

It must be admitted that much remains to be known about the true *H. atherstoni*. As yet, we are without information regarding the limits of individual variation, the characters of shape and sculpture in successive growth-stages from early youth onwards, and the course of the septal suture throughout the individual development. This information can only be obtained by the examination of an extensive suite of specimens, and in the meantime it is not possible to form a decided opinion on the question of identity with the Swiss specimens dealt with by Baumberger. It seems necessary, with the present imperfect data for comparison, to regard that question as still awaiting settlement. At the same time, we may presume the relationship between these Swiss and South African forms to have been so intimate as to furnish further highly suggestive evidence for a correlation between the Uitenhage beds and the strata situated about the base of the Hauterivian in Europe.

It may be noted that Baumberger gives reasons for considering that the form from the Hauterivian of the Maritime Alps ascribed by Kilian\* to *H. atherstoni*, is not identical with the supposed *H. atherstoni* from the Swiss Jura, above discussed.

It has been stated by Sayn and Roman that *Holcostephanus atherstoni* occurs in the Hauterivian inférieur at localities in Languedoc.† In answer to an inquiry concerning this French form, M. Roman very courteously sent me three specimens from the Lower Hauterivian of Saturargues (Hérault) which had been determined by M. Kilian. Two of the specimens were named *H. atherstoni*, and the third, a very finely ribbed example, somewhat flattened laterally by crushing, bore the name *H. sayni* Kilian. After a careful examination of these three specimens I was unable to satisfy myself that they represented two separate species. All three are very finely

\* Kilian (4), p. 865, pl. lvii., fig. 1.

† Sayn and Roman (1), pp. 623, 625, 629, 632, 638, 639.

ribbed, and though the ribs seemed most crowded in the specimen referred by M. Kilian to *H. sayni*, yet the differences in this respect did not appear to me to be at all considerable, and other points of distinction, such as the more discoidal form, were probably to be accounted for by distortion through crushing. A comparison of these specimens with Sharpe's type, and other examples of *H. atherstoni*, shows that in *H. atherstoni* the shell is much more inflated and less discoidal: the whorl is broader in section and less highly arched. The umbilicus is relatively much narrower and more profound. The umbilical wall falls more abruptly and steeply into the umbilical cavity. The involution is greater. In the French specimens the umbilicus is of a broader and shallower type, and the involution is such that the tubercles, together with part of the ribbing of the flank, are visible in the penultimate whorl. The involution, in fact, is less than in the last whorl of the considerably larger type-specimen of *H. atherstoni*. The primary (umbilical) ribs are also much more weakly developed than in *H. atherstoni*. The ribbing of the flank and periphery of *H. atherstoni* is of a somewhat coarser type, and the ribs are rather more prominent and are less closely crowded together than those of the French specimens. At a selected stage of growth comparable in the two forms, a space of 20 mm. along the periphery includes 9 ribs in *H. atherstoni* and 13 in the French shells. In *H. sayni* an occasional bifurcation of a rib, or the intercalation of a shorter rib between two longer ones, may be observed to occur on the flank at a varying but usually considerable distance away from the tubercles. In *H. atherstoni*, the ribs of the flank all have their commencement either at, or in the near vicinity of, the tubercles, and bifurcation of the ribs has not been observed on any part of the flank.

It is clear, therefore, that these French specimens are not very closely comparable with *H. atherstoni*, and I think it highly probable that all three represent *H. sayni* Kilian,\* a finely ribbed species very nearly allied to *H. astierianus* (d'Orb.).

A specimen from the Neocomian of Speeton (zone of *Belemnites jaculum*), preserved in the Scarborough Museum, was figured by Pavlow (*Bull. Soc. Imp. Nat. Mosc.*, 1892, pl. xvii., fig. 14) and considered by him to be identical with *H. atherstoni*. Through the kindness of Mr. H. Ascough Chapman and Mr. J. A. Hargreaves, of Scarborough, I have been able to compare this Yorkshire individual with Sharpe's type and other examples of *H. atherstoni* from South

\* Kilian and Leenhardt (1), p. 976; Sarasin and Schöndelmayer (1), part 1, p. 38, pl. iv., figs. 2, 3; d'Orbigny (1), pl. 28, fig. 4.

Africa. The specimen is preserved unfavourably for an exhaustive comparison, but certainly bears a very close resemblance to *H. atherstoni*, particularly in the inflation of the whorls and the general character of the ribbing. Some readily apparent differences may at the same time be noticed. At a comparable stage of growth the Speeton form is distinctly more closely and more delicately ribbed; umbilical ribs are hardly defined, and certainly have not attained the development to be observed at a similar stage in *H. atherstoni*. A further point is that in all specimens of *H. atherstoni* the flattened umbilical marginal tubercles have either a slight backward direction when traced towards the flank, or their disposition is strictly radial; in the Yorkshire example, on the other hand, the tubercles have a strong forward inclination. These differences cannot be overlooked, and they strongly suggest that the Speeton form may not be identical with that from South Africa; but it must be admitted that the two approximate very closely to one another. It may suffice to have drawn attention to these points of difference while refraining from any final expression of opinion concerning the intimate relationship of these forms—a question which can only be ultimately settled by the comparison of further material. At the same time, I am inclined to think that the Speeton form will not be found to be identical with *H. atherstoni*.

Other finely ribbed specimens from the lower part of the zone of *Belemnites jaculum* at Speeton, which have been referred by Prof. Pavlow and Mr. C. G. Danford to *Holcostephanus astierianus* (d'Orb.), are also in some respects comparable with *H. atherstoni*; but they are usually of small size, and a satisfactory comparison with the much larger available examples of *H. atherstoni* is difficult. One such individual, in which the development of constrictions does not form a feature, has been figured by Mr. Danford under the name *Olcostephanus* (*Astieria*) *astieri*.\* It is laterally compressed and relatively highly arched, and the umbilical ribs are very weakly developed and are not backwardly inclined. The secondary ribbing, which is of a very crowded and delicate character, has a stronger forward inclination than that of *H. atherstoni*. The tubercles also have a forward inclination, which is not the case in the African species.

Karakasch has described a *Holcostephanus* from the Lower Cretaceous of Biassala (Crimea) under the name *Holcostephanus* (*Astieria*) cf. *atherstoni* Sharpe.† It appears, from the figure given

\* Danford (1), pl. xi., figs. 7, 7a.

† Karakasch (1), p. 103, pl. i., fig. 3.



by Karakasch, to differ from the African species by the relatively wider umbilicus and less degree of involution, but to resemble it in possessing backwardly inclined umbilical ribs. Kilian has described an ammonite from the Hauterivian of the neighbourhood of Escrag-nolles (Maritime Alps) as *Holcostephanus guebhardi*,\* and states that this corresponds to *H. atherstoni* Karakasch, but not to the type of Sharpe. In the specimen figured by Kilian the ribs of the flank are strictly radial in direction, so that there is no close agreement with *H. atherstoni*.

Another form which may be somewhat nearly related to *H. atherstoni* is *H. schenki* (Oppel), from the Spiti Shales in Tibet,† but this is less densely ribbed and is further distinguished by the more flattened arch of the whorl-section, and by the presence of strongly marked constrictions.

An inflated form from the so-called "Gault" on the Island of Chasik and from Tukusitnu Bay (Alaska), figured by Eichwald as "*Ammonites astierianus* d'Orb. aff." and compared by him with Roemer's *Ammonites multiplicatus*, may perhaps be related to *H. atherstoni*; but according to Eichwald's insufficient figure the primary ribs are almost exactly direct (radial) in their course. A complete comparison with this unsatisfactory figure is impossible, since a side view only is given.‡

#### HOLCOSTEPHANUS cf. ATHERSTONI (Sharpe).

A single specimen from the Sunday's River, in the collection of the South African Museum, agrees very closely with Sharpe's type in all points except one—the inflation of the shell. The whorl-section has rather greater breadth in relation to its height, and the peripheral area presents a more broadly rounded surface and is less highly arched in sectional view than that of *H. atherstoni*. The shell accordingly retains a rather more globose aspect, the flank of the whorl is less extensive and less flattened and becomes more insensibly merged in the broad peripheral area, while the umbilical cavity is correspondingly rather more profound. The dimensions of the specimen, which comprises a considerable part of the body-chamber, are as follows:—

Greatest diameter .....	130 mm.
Greatest breadth of the last whorl in cross-section (estimated) .....	95 „

\* Kilian (4), p. 866, pl. lvii., figs. 2a, 2b.

† Oppel (2), p. 286, Tab. 81, figs. 4a-4c; Uhlig (4), p. 130, pl. xviii., figs. 2a-2c.

‡ Eichwald (2), pl. viii., fig. 13.

Greatest height of the last whorl at the centre, in section 35 mm.  
 Greatest diameter of the umbilicus, measured from the  
 umbilical rim between the tubercles ..... 48 ,,

In the type-specimen of *H. atherstoni* the maximum diameter is 140 mm., the greatest breadth of the last whorl 90 mm., and the height of the last whorl in section at its anterior part 42 mm. It is thus seen that the height of the whorl-section in relation to its breadth is somewhat different. In the more inflated specimen, when the breadth of the whorl is 86 mm. its height at the centre is 32 mm.; in *H. atherstoni* (type-specimen) I have estimated that with a breadth of 86 mm. the height is 40 mm. The two left-hand specimens, depicted in greatly reduced size, in a text-figure published by Drs. Hatch and Corstorphine,\* may perhaps represent this inflated form.

Mr. G. C. Crick has shown me a specimen in the British Museum (registered 46534) which closely agrees with the one here discussed. It is from the Sunday's River (from A. G. Bain's collection), and has at some time been determined as *Olcostephanus atherstoni*. It has an inflated form and breadth of whorl-section which seem to distinguish it from *H. atherstoni*, as exemplified by Sharpe's figured type, in the manner described above in the case of the other specimen. The greatest diameter of this individual in the British Museum is 145 mm. The greatest breadth of the ultimate whorl would, when complete, have been almost 100 mm., while the height of this whorl at the centre at its anterior end would have slightly exceeded 35 mm. In the breadth of the umbilicus and in all other characters there is the closest agreement with the specimen from the South African Museum. This would seem to indicate that fixed and reliable characters are exhibited which may suffice to separate this more globose shell from the true *H. atherstoni*, and it might perhaps be possible to establish the constancy of these distinctive features were a suite of specimens of undoubted *H. atherstoni*, at a suitable stage of growth, available for comparison. Unfortunately this is not the case, and the only specimen of *H. atherstoni* that I have seen which illustrates a comparable stage is Sharpe's figured type. Comparison with this has revealed the slight shape differences above noted, but beyond this there is entire agreement; the characteristic ornamentation, the degree of involution and the width of the umbilicus are the same. There is as yet no material for a comparison of the septal sutures. I therefore do not yet feel justified in proposing a new specific name for the specimens here

\* Hatch and Corstorphine (1), p. 243, fig. 65 (as *Olcostephanus bainii*).

dealt with, and whatever may ultimately become known regarding their exact relationship to *H. atherstoni*, which they so closely resemble, it is certain that so far as present evidence goes, this relationship must be presumed to be very intimate.

HOLCOSTEPHANUS WILMANÆ sp. nov.

Plate IX., figs. 1, 1a.

*Description of a Single Specimen.*—The shell is laterally much compressed and is discoidal in form; the flattened flanks of the ultimate whorl are relatively extensive, while the peripheral area is narrow and presents a somewhat flatly convex surface. The whorl is narrow and highly arched in section, and the height of the whorl-section, measured at the middle, is almost equal to the breadth, which is greatest at the umbilical margin. The whorl, however, is almost parallel-sided, so that the breadth of its section taken at the middle of the flank is little less than at the umbilical tubercles. The involution is such that about two-thirds of the preceding whorl are embraced.

The umbilicus is relatively shallow, and occupies one-third of the total diameter. The umbilical rim is not abruptly defined, but the surface of the flank curves down somewhat gradually to the umbilical wall, which falls very steeply to the spiral suture. Primary umbilical ribs commencing at the suture slope back very obliquely, and, quickly gathering strength, swell up at the umbilical rim to form strong, elongated, much-compressed tubercles, present to the number of eighteen in the ultimate whorl. The secondary ribs proceed from the tubercles chiefly in groups of three, but there are occasionally four ribs in a group in the ultimate whorl, and frequently a rib is inserted so as to terminate between two tubercles. The ribs at first swing forwards from the tubercle, and bend back at the middle of the flank to take an almost direct course across the periphery. The ribs are prominent in character, and on the peripheral area in the anterior part of the last whorl their crests are 4 mm. apart.

Immediately behind the oral margin is a strong constriction, and a portion of a lateral auricular extension is preserved.

*Dimensions.*—

Greatest diameter .....	90 mm.
Greatest breadth of the last whorl in cross-section.....	30 „
Height of the last whorl at the centre, in section.....	28 „
Greatest diameter of the umbilicus, measured from the umbilical rim between the tubercles .....	30 „



*Occurrence.*—The specimen is in the collection of the Geological Society of London (registered 10975A), and the label affixed to it bears the following record of locality and collector: "Aasvogel Krantz above Modder Drift, Sunday's River, S. Africa. Dr. Atherstone, F.G.S., 1876."

*Remarks.*—The individual above described is almost complete, comprising the body-chamber, but the exact length of this cannot be ascertained, nor is the shell so preserved that the lobe-line is anywhere visible. The specimen has undergone some distortion from crushing, but making every allowance for this, it is clear that we are dealing with a form well distinguished by its high whorl-section and extensive flattened flanks. In the discoidal form, the relatively shallow umbilicus, and the degree of involution, we are reminded of *H. astierianus* (d'Orb.),\* but *H. wilmanæ* is readily separated from this by its very strong, oblique umbilical ribs and tubercles, and by the inclination and the coarseness of the secondary costæ.

This appears to be the specimen mentioned by Pavlow† as a compressed variety of *H. atherstoni*, but it was recognised that the distinctive characters are sufficient to warrant a new specific name (*op. cit.* p. 492). As pointed out by Pavlow, the specimen is distinguished from the typical *H. atherstoni* by the presence of rather fewer umbilical ribs and by the more strongly developed secondary costæ. In addition, *H. atherstoni* is a considerably more strongly inflated shell, and has a relatively narrower and much more profound umbilicus. The points of distinction are in fact so great that the only course open is to definitely separate the two forms.

There is much stronger resemblance to *H. psilostomus* Neum. and Uhlig,‡ from the Neocomian of North Germany. The ribbing is of very similar character, but in *H. psilostomus* the umbilical ribs are rather more numerous, the breadth of the umbilicus is somewhat greater relatively to that of the flank, and the shell, although much more laterally compressed than *H. atherstoni*, is still considerably more inflated and less discoidal than in *H. wilmanæ*. I believe that the presence of the above characters of distinction must be considered sufficient to warrant the provisional separation of these two forms, but there can be little doubt that the relationship is intimate, and there is no other known *Holcostephanus* with which *H. wilmanæ* can be brought into such close comparison.

\* d'Orbigny (1), p. 115, pl. 28, fig. 1 (1840).

† Pavlow and Lamplugh (1), p. 496 (p. 138 of authors' copy).

‡ Neumayr and Uhlig (1), p. 149, Taf. xxxii., fig. 2.

A shell from the Lower Hauterivian of North Germany described by von Koenen \* under the name *Astieria* aff. *psilostoma* also shows great similarity to *H. wilmanæ*, but may be readily distinguished by the wider umbilicus, the strongly developed constrictions, and the more inflated and less discoidal form of the whorls.

Pavlov thought that small specimens from the Neocomian of Spain, figured by Nicklès † as *Holcostephanus hispanicus*, might possibly belong to this form; but though a thorough comparison with these figures is difficult, and the character of the ribbing appears to be very similar, it seems to me most probable that the much greater inflation of the Spanish shell would be found sufficient to separate it. If the specimen figured by Nicklès in fig. 11 represents the same form as that depicted in fig. 3, then it is clear that *H. wilmanæ* is a much more discoidal shell. The small specimen represented by Nicklès in fig. 10 is only drawn in side view, but it appears to possess a prominence of the umbilical rim and a depth of the umbilical cavity which may be taken to indicate the somewhat strongly inflated character of the shell. Pavlov draws attention to the existence of two specimens which he identifies with the South African form above described; the one is from Aigles (Basses-Alpes), preserved in the Pictet collection in the museum at Geneva, and the other, from the Shasta group of California, is in the geological collection of the University of Moscow.

*Holcostephanus tönsbergensis* (Weerth), ‡ from the Neocomian of the Teutoburger Wald, may possibly also be related, so far as can be judged from a comparison with Weerth's figure 4.

#### HOLCOSTEPHANUS BAINI (Sharpe).

1856. *Ammonites bainii* D. Sharpe, Trans. Geol. Soc. Lond., ser. 2, vol. vii., p. 197, pl. xxiii., fig. 2.

1882. *Olcostephanus baini* M. Neumayr, in E. Holub and M. Neumayr, Denkschr. d. k. Akad. Wiss., Math-Nat. Cl., Band xlv., p. 272.

Although no specimen undoubtedly referable to this form is included in the collection under examination, a few remarks under this heading may be useful as a preface to the account of an individual, to be described below, which I believe to be very closely related to *H. baini*.

\* von Koenen (2), p. 151, Taf. liv., fig. 2.

† Nicklès (1), pl. ix., figs. 3 and 10.

‡ Weerth (1), p. 16, Taf. iv., fig. 4.

*Occurrence.*—*H. bairni* has been found at localities on the Zwartkop's and Sunday's Rivers, and its occurrence in the Zwartkop's River Valley below Uitenhage has been noted by Messrs. Rogers and Schwarz.\* Specimens in the collection of the Geological Society (Sharpe's type, registered 10976A) and in the British Museum (registered 52052) are from the Sunday's River.

*Remarks.*—Neumayr thought *H. bairni* to be most closely related to *H. schenki* (Oppel),† from the Spiti Shales of Tibet, and there is indeed a great resemblance between the two in all the more important features; but *H. bairni* is more closely ribbed, and as mentioned by Uhlig,‡ in regard to the fineness of the ribbing, *H. schenki* occupies a position just midway between *H. bairni* and *H. atherstoni*. Neumayr and Uhlig § also thought close relationship to exist between *H. bairni* and *H. keyserlingi* Neum. and Uhl. from the Neocomian of North Germany, but the manner of division of the ribs is really a strong distinguishing feature. In *H. bairni* none of the ribs bifurcate after leaving the nodes. The relationship of *H. bairni* to *H. diptychus* (Keys.) and *H. polyptychus* (Keys.) || from Petschora-Land is also no doubt much more remote than Neumayr supposed, and these forms, as well as *H. keyserlingi*, clearly do not belong to the same division of the *Holcostephani* (sensu lato) as *H. bairni* and *H. schenki*. Nikitin,¶ in fact, has strongly criticised Neumayr's suggestion of relationship between *H. schenki* and these two ammonites from Petschora-Land, and Pavlow has also referred to this matter.\*\*

Remarks on the points of resemblance between *H. bairni* and *H. rogersi* sp. nov. will be found appended to the description of the latter given in these pages.

Neumayr †† dealt fully with the question of a suggested resemblance between *H. bairni* and a Jurassic ammonite from Madagascar ascribed to J. Sowerby's *Ammonites herveyi*,‡‡ and showed that these really have no significant characters in common. The points of resemblance are in fact so slender as not to merit further discussion here; but it may be remarked that Neumayr probably misrepresented the case when he wrote as follows: "Newton thinks to have found close relationship between *Macrocephalites herveyi* from Madagascar and *Olcostephanus bairni* Sharpe from the Uitenhage

\* Rogers and Schwarz (1), p. 7.

† Oppel (2), p. 286, Tab. 81, figs. 4a-c; Uhlig (4), p. 130, pl. xviii., figs. 2a-c.

‡ Uhlig (4), p. 132.

§ Neumayr and Uhlig (1), p. 156.

|| Keyserling (1), p. 327, pls. xx., figs. 4, 5; xxi., figs. 1-3; xxii., figs. 9, 10.

¶ Nikitin (1), p. 122.

\*\* Pavlow and Lamplugh (1), p. 488 (p. 130 of authors' copy).

†† Neumayr (5), p. 6.

‡‡ Newton (1), p. 334.



Formation." In the description of the Madagascar fossils, the opinion that these two forms are truly related was not expressed, and it is not necessary to infer that such a view was actually entertained.

Kilian \* has suggested that *H. baini* may represent an immature stage of *H. atherstoni* (Sharpe), but this is certainly not the case. *H. atherstoni* at a comparable growth-stage is much more finely ribbed, to mention only one point of distinction.

With regard to the type-specimen of *Ammonites baini* Sharpe, preserved in the collection of the Geological Society, it is perhaps well to note that in the late Prof. J. F. Blake's published list of the types and figured specimens in the Society's museum, reference is accidentally made to a wrong specimen.† The individual figured by Sharpe was unfortunately overlooked by Mr. C. D. Sherborn when preparing a manuscript catalogue of the collection some years ago. The specimen erroneously noted as the type (registered 10976) was presented by Atherstone and bears the date 1876; ‡ I consider it to represent a hitherto undescribed form, and it is dealt with in these pages under the name *Holcostephanus modderensis*.

HOLCOSTEPHANUS cf. BAINI (Sharpe).

Plate IX., fig. 2; X., fig. 1.

A single specimen, from the collection in the South African Museum, agrees so closely with Sharpe's *Ammonites baini* that it has seemed questionable whether it should not be considered identical.

*Description*.—The specimen, which is considerably larger than known examples of *H. baini*, consists of at least four whorls, and the form of these as well as the degree of overlap in the earlier whorls is the same as in *H. baini*. Some of the shell substance is retained and the specimen is partly preserved as a cast, but it exhibits in very imperfect manner the course of the septal sutures, so that these cannot be satisfactorily copied for illustration. The body-chamber is not preserved. In the interior whorls the umbilical wall of each whorl falls upon the umbilical tubercles of the preceding whorl, but in the latter half of the last whorl the degree of involution becomes slightly reduced, so that the nodes of the preceding whorl are completely exposed and the beginnings of the flank ribs proceeding from them can be just discerned. At the same

\* Kilian (4), p. 865.

† Blake (2), p. 59.

‡ Sharpe's figure of *H. baini* was published in 1856.

time, the slope of the umbilical wall of the last whorl becomes slightly less steep.

There are sixteen strong umbilical marginal tubercles in the last whorl preserved, and from these the ribs of the flank and periphery proceed most frequently in groups of three, though occasionally only two ribs are given off from the nodes. Sometimes a rib may be situated between two nodes at one of its extremities, while springing from a node at its opposite end. These relations of the ribs, however, are the same in *H. baini*. The ribs as they depart from the tubercles to cross over the periphery are not forwardly inclined, but pass almost straight across the whorl. In the most advanced portion of the specimen the crests of the ribs upon the peripheral area are situated at a distance of 6 mm. apart. Well-marked constrictions are present as in *H. baini*.

*Dimensions.*—

Greatest diameter of specimen .....	92 mm.
Greatest breadth of last whorl in cross-section .....	53 „
Greatest height of last whorl at the centre (section) .....	24 „
Greatest diameter of the umbilicus, measured from the umbilical rim between the tubercles .....	45 „

*Occurrence.*—This specimen is believed to come from the Sunday's River.

*Remarks.*—There can be no doubt that the form here represented is very closely related to *H. baini*, and I was for some time undecided whether definitely to identify the two. Allowing for the difference in dimensions between this specimen and the examples of *H. baini* that I have seen, which are smaller, the only apparently valid character of distinction is in the disposition of the ribs. In *H. baini* the ribs proceeding over the whorl from the nodes have a well-marked forward throw, but such an inclination is not seen in the specimen above described. Mr. G. C. Crick, who has kindly examined the specimen, considers that this is a significant point of distinction, but admits that in other respects the two forms are very closely similar. With regard to the inclination of the ribs as a constant and reliable character, it may be remarked that in the British Museum collection a specimen of *H. baini* (registered 52052) which strikingly resembles Sharpe's type in all other points, agrees with it also in showing the same inclination of the ribs. It therefore appears evident that in this character of the ribbing we have a distinctive feature for separation, whatever this alone may be worth. There is unfortunately as yet only a single specimen available for comparison, and since in other respects it shows such close agree-

ment with *H. baini*, I am unable to arrive at a definite opinion as to the nearness of its relationship to that form, and feel hardly justified in proposing a new specific name. It is to be hoped that the acquisition of additional material may enable a more thorough comparison to be made and lead to a clearer knowledge of the actual relationships.

The specimen has much general resemblance to *H. rogersi* sp. nov., but is more coarsely ribbed. In *H. rogersi*, too, the ribbing shows a still greater departure from that of *H. baini*, in that the secondary costæ as they proceed from the tubercles are not truly direct in their course across the periphery, but have a very slight backward throw.

HOLCOSTEPHANUS ROGERSI sp. nov.

Plate IX., fig. 3 ; X., fig. 2.

*Description of a Single Specimen.*—The shell is involute to the umbilical tubercles, and the ultimate whorl is broad in section and broadly rounded on the peripheral area. The umbilical wall falls very steeply and the umbilical rim is bluntly rounded. The primary ribs, commencing above the spiral suture, are narrow, and rather weakly developed. They have a slight backward slope as they are traced up to the marginal nodes. There are about sixteen of these laterally compressed, not very prominently developed tubercles in the ultimate whorl. From these the ribs of the flank proceed mostly in groups of three, though there are occasionally only two ribs terminating at a node, or a rib-ending may now and then fall between two nodes. These ribs as they pass from the tubercles over the peripheral area are very slightly reclined, that is, have a backward slope in relation to a radius. In the anterior portion of the ultimate whorl the crests of the ribs on the peripheral area are separated from one another by a space of 3 mm.

Two strongly developed constrictions are visible on the ultimate whorl, and they are situated opposite to one another. The specimen is entirely septate, but so preserved that the figure of the lobe-line cannot be traced.

*Dimensions.*—

Greatest diameter .....	63 mm.
Greatest breadth of the last whorl in cross-section .....	40 "
Height of the last whorl at the centre, in section .....	16 "
Greatest diameter of the umbilicus, measured from the umbilical rim between the tubercles.....	25 "

*Occurrence.*—The specimen, in the collection of the South African Museum, is from the Sunday's River.



*Remarks.*—Although I have only seen a single specimen, and the state of preservation of this is not so good as might be desired, I have no hesitation in pronouncing it to represent a hitherto undescribed form. It is apparent that though distinctively characterised, particularly by the feature of reclined costation, this ammonite may be brought into closest relationship with *H. baini* (Sharpe) and *H. schenki* (Oppel), and particularly with the latter. *H. baini* has the whorl relatively narrower and more highly arched in section, while its ribbing is noticeably coarser. On the peripheral part of the whorl at a comparable stage there are seven ribs in *H. rogersi* within a space which includes only six ribs in *H. baini*. Moreover, the ribs in *H. baini* have a marked forward inclination as they depart from the nodes.

Reference to the published descriptions and figures of *H. schenki*,\* from Shangra, east of Puling (Tibet), seemed to show a very close resemblance between the two forms, but I have been able to supplement this by an actual comparison with Oppel's type-specimen in the State Palæontological Collection at Munich, and when making this comparison I was fortunate in having the kind assistance of Prof. J. F. Pompeckj. *H. schenki* has rather more numerous umbilical tubercles and is slightly more densely ribbed than *H. rogersi*. In *H. schenki* the umbilicus is relatively a little wider and in cross-section the whorl is rather wider between the umbilical rims, in relation to the height. The most notable point of distinction, however, is in the course taken by the secondary ribs as they pass from the tubercles over the periphery. In *H. schenki* they have a forward inclination, while in *H. rogersi* they are slightly reclined.

There is considerable resemblance between *H. rogersi* and *H. quebhardi* Kilian,† from the Hauterivian of the neighbourhood of Escragnolles in the Maritime Alps, but in *H. quebhardi* the ribbing of the flank is strictly radial in direction.

#### HOLCOSTEPHANUS MODDERENSIS sp. nov

Plate X., figs 3, 3a.

1892. *Astieria schenki* A. P. Pavlow (*partim*), Bull. Soc. Imp. Nat. Mosc., année 1891, Nouv. Sér., tome v., p. 493 (p. 135 of authors' copy).

*Description of a Single Specimen.*—The shell has rapidly expanding whorls, and is involute to the umbilical marginal tubercles in the

\* Oppel (2), p. 286, Tab. 81, figs. 4a-c; Uhlig (4), p. 130, pl. xviii., figs. 2a-c.

† Kilian (4), p. 866, pl. lvii., figs. 2a, 2b.

most advanced stage represented in this individual, in which the ultimate whorl is not complete anteriorly. The greatest breadth falls at the umbilical rim, and in section the ultimate whorl is very broad in relation to its height; the peripheral area forms a broadly flattened arch. The umbilical wall falls very steeply and abruptly from the rounded rim, and the relatively narrow umbilicus has the form of a profound and acutely pointed funnel.

The umbilical ribs, commencing above the spiral suture, are narrow, and they are slightly backwardly directed as they pass up into the compressed and fairly prominent marginal tubercles. There are sixteen of these flattened tubercles in the ultimate whorl, and from them the secondary costæ proceed mostly in regular groups of three, though from two of the nodes four ribs are given off. The secondary ribs follow a direct course from the nodes across the periphery except near the anterior part of the whorl, where a few of them appear to have a very slight forward inclination. This, however, may possibly be due to an accident of preservation, and may stand in relation to a slight distortion exhibited by the specimen in its anterior part. The ribs crossing the periphery are fairly prominent, and at the anterior part of the peripheral area the crests of adjacent ribs are situated at 4 mm. apart from one another. On the last whorl there is a single deeply impressed constriction.

In this specimen the shell is in great part preserved, and the course of the septal sutures remains unknown. The ultimate whorl seems to comprise a part at least of the body-chamber.

*Dimensions.*—

Greatest diameter .....	80 mm.
Greatest breadth of the last whorl in cross-section .....	68 "
Height of the last whorl at the centre, in section .....	25 "
Greatest diameter of the umbilicus, measured from the umbilical rim between the tubercles .....	28 "

*Occurrence.*—The specimen is from the Modder Drift, Sunday's River, and is preserved in the collection of the Geological Society of London (registered 10976).

*Remarks.*—The specimen here described was thought by Pavlow to represent *H. schenki* (Oppel). It bears a label "*Ammonites baini* Sharpe, Jurassic, Modder Drift, S. Africa. Dr. Atherstone, F.G.S., 1876," and the descriptive details given by Pavlow (*op. cit.*, p. 493) apply to it accurately. I am convinced that this African form is so characterised that it cannot rightly be united with *H. schenki*, and though it appears highly probable that the two are

very closely related, I believe that the following points fully justify the separation. In *H. modderensis* the whorl increases more rapidly in breadth and the involution is stronger than in *H. schenki*. The umbilicus is relatively narrower and the umbilical wall falls more steeply in *H. modderensis*, in which also the umbilical ribs, at least in the ultimate whorl, have a definite posterior inclination when traced up towards the tubercles. In cross-section, the whorl is considerably broader in proportion to height than in *H. schenki*. Further, not only is the ribbing of *H. modderensis* at a comparable stage somewhat coarser, but the costæ as they pass from the tubercles across the periphery mostly follow a straight course, while in *H. schenki* they have a well-marked forward inclination.

It is scarcely necessary to make a detailed comparison between *H. modderensis* and *H. rogersi*, described above. *H. modderensis* is a much more inflated and globose shell, and the rate at which the whorls increase in breadth is considerably more rapid; the umbilicus is also relatively narrower, and the breadth of the whorl-section proportionately greater than in *H. rogersi*.

*H. baini* (Sharpe)\* is no doubt a related shell, but *H. modderensis* is well distinguished from this by its inflated form, the great breadth and diminished height of the whorl-section, the rapid increase in breadth of the whorl, the narrower umbilicus, and the direct course of the secondary ribs as they cross the periphery. *H. modderensis* is also considerably more densely ribbed than *H. baini*.

One of the forms figured by Pictet as *Ammonites bidichotomus* Leym.,† which Pavlow considered identical with Oppel's *H. schenki*, appears to be well distinguished from *H. schenki* by the coarser ribbing, the direct course of the secondary ribs, and the absence of noticeable constrictions. As far as it is possible to make comparison by means of Pictet's figures, the Swiss shell seems to approach more closely to *H. modderensis*, though at the stage represented it is less strongly involute. A satisfactory comparison between this figure of a small specimen and the relatively large specimen of *H. modderensis* is, however, not possible.

A specimen from Neuchatel figured by Pictet as *Ammonites astierianus* d'Orb.‡ was united with *Ammonites spitiensis* Blanford by

\* Sharpe (1), p. 197, pl. xxiii., fig 2.

† Pictet and Campiche (1), pl. xli., fig. 3 (1860).

‡ Pictet and Campiche (1), pl. xliii., fig. 2 (1860).



Pavlow,\* but a reference to Uhlig's † description and figures of *Holcostephanus spitiensis* shows this to have been an error. Pictet's figure represents an inflated form which has some resemblance to *H. modderensis*, but it differs from this by its relatively higher whorl-section, less strong involution, and greater number of umbilical ribs. Here again, the comparison cannot be quite satisfactorily made, because Pictet's figure is drawn in half the natural size, and the original specimen would have attained a stage when its dimensions were almost twice those of the individual of *H. modderensis* compared.

It is also difficult to make comparison with the small inflated specimens from Berrias (Ardèche) figured by Pictet under the name *Ammonites astierianus*.‡ These might conceivably represent an earlier stage in the growth of such a form as *H. modderensis*, but if this be the case some changes in the degree of involution and in the form of the whorl-section would have to follow. While of apparently very similar type to *H. modderensis*, at the stage represented in Pictet's figure the involution is less strong and the whorl more highly arched in section, and relatively narrower. Pictet's "Variété No. 3," from the same place,§ while possessing a broad and depressed whorl-section, is still more strongly distinguished from *H. modderensis* by the much wider umbilicus and the diminished involution. The specimens represented in Pictet's plate 17, figs. 3 and 4, were considered by Pavlow to be *Holcostephanus spitiensis* (Blanf.), but I believe this view to be erroneous. They seem to me to illustrate a form probably more aptly comparable with *H. modderensis* than with either *H. spitiensis* or the true *H. astierianus* with which they were at first identified.

An ammonite from the Tithonian of Stramberg, figured by Zittel|| under the name *Ammonites grotianus* Opp., and thought by Pavlow to represent *Holcostephanus spitiensis* (Blanf.), is believed by Uhlig¶ to be distinct from both of these and to stand nearer to the true "*Astieria*." It has a whorl-section and inflated form somewhat resembling that of *H. modderensis*, but it is a more widely umbilicate shell, and at the stage of growth represented in Zittel's figure there is a marked difference in the relation of the secondary ribs to the umbilical tubercles.

\* Pavlow and Lamplugh (1), p. 497 (p. 139 of authors' copy).

† Uhlig (4), p. 89, pl viii., figs. 1-3.

‡ Pictet (1), p. 86, pl. 17, figs. 3, 4.

§ Pictet (1), p. 86, pl. 18, fig. 3.

|| Zittel (3), p. 90, pl. 16, figs. 3, 4.

¶ Uhlig (4), p. 94.

## HOLCOSTEPHANUS UITENHAGENSIS sp. nov.

## Plate XI.

1905. *Olcostephanus bainii* F. H. Hatch and G. S. Corstorphine (*partim*). The Geology of South Africa, p. 243, fig. 65 (right-hand specimen only).

*Description of a Single Specimen.*—The specimen is preserved chiefly in the form of a cast which in the greatest portion of the ultimate whorl has retained, though somewhat imperfectly, the impress of the external costate ornaments. The specimen is also slightly distorted by pressure.

The shell has a laterally compressed aspect, and the whorls are relatively narrow and highly arched in section. The flanks are broad and flattened in form, while the peripheral area presents a somewhat narrowly convex surface. The involution is such that about two-thirds of the flank of the preceding whorl are embraced, thus leaving a considerable space free between the spiral suture and the umbilical margin of the preceding whorl. The greatest breadth of the whorl is at the umbilical margin, though the breadth at the middle of the flank is little less than this until the anterior portion of the ultimate whorl is reached, when the whorl is relatively rather more inflated.

The umbilical margin is abrupt, and the umbilical wall falls almost vertically until traced to the last half of the ultimate whorl, where the wall slopes with slightly decreasing steepness. Umbilical ribs are not developed in the last whorl. The umbilical marginal tubercles, present to the number of fifteen in the last whorl, are not strongly compressed in form, and they are well spaced. The ribbing of the shell is relatively fine, and in the ultimate whorl three or four costæ proceed from each tubercle, in addition to which there are some costæ which terminate between the tubercles and occasionally a rib may become intercalated on the flank. There is no evidence that any bifurcation of the costæ occurs on the flank. The ribs as they pass towards the periphery are forwardly inclined, more noticeably so in the anterior half of the ultimate whorl, where, on the peripheral area, adjacent ribs have their crests 6 mm. apart. The development of constrictions is very weak and inconspicuous.

*Dimensions.*—

Greatest diameter.....	22	cm.
Greatest breadth of the last whorl in cross-section .....	9	„
Height of the last whorl at the centre, in section.....	6	„
Greatest diameter of the umbilicus, measured from the umbilical rim between the tubercles .....	7.5	„

*Occurrence.*—In clay between two hard calcareous bands in the railway cutting between milestones  $24\frac{1}{2}$ – $24\frac{3}{4}$  on the Graaff-Reinet railway, about three miles from Uitenhage (276).

*Remarks.*—The specimen here described was referred to by Messrs. Rogers and Schwarz \* as “an *Olcostephanus* . . . allied to *O. atherstoni*,” and it was rightly stated to be distinguished from this by “being more compressed laterally, in having no umbilical ribs, and in the less overlapping of the whorls.” *H. uitenhagensis* is considerably more discoidal in form, and the rate of increase in the breadth of the whorl-section is much less than in *H. atherstoni*; the umbilicus is also very much wider and relatively shallower than in Sharpe’s type. The ribbing of these two forms is of closely similar character, and both agree also in the very inconspicuous development of constrictions.

In the lateral compression of the shell and the fine character of the ribbing, the wide umbilicus and the degree of involution, *H. uitenhagensis* is more reminiscent of the typical *H. astierianus* (d’Orb.) † than of some of the more coarsely ribbed and inflated *Holcostephani* that occur in the Uitenhage Series; but the points of distinction are so marked that a detailed comparison with *H. astierianus* is unnecessary. The same remarks apply when we attempt a comparison between *H. uitenhagensis* and *H. sayni* Kilian, ‡ the finely ribbed form which was originally thought to be identical with *H. astierianus*. In general habit there is similarity to the finely ribbed *H. filosa* (Baumberger) § from the Hauterivian of the Swiss Jura, but the two forms are far from being identical.

## GENUS ACANTHODISCUS V. Uhlig.

### ACANTHODISCUS sp.

*Description of a Single Specimen.*—The specimen consists of a fragment of the chambered part of a large whorl. It measures about 70 mm. from end to end along the periphery, and the cross-section at the anterior end is 35 mm. in height and about the same in breadth. The specimen is considerably weathered, and has had the shell partially removed, showing here and there a portion of the lobe-line and displaying the siphuncle near the posterior end. The whorl is slightly flattened on the sides and evenly and broadly

\* Rogers and Schwarz (1), p. 10. † d’Orbigny (1), pl. 28, fig. 1 (1840).

‡ Kilian and Leenhardt (1), p. 976; Sarasin and Schöndelmayer (1), part 1, p. 38, pl. iv., figs. 2, 3.

§ Baumberger (1), 4<sup>er</sup> Theil, p. 31, pl. xxiii., figs. 2a, 2b.



arched in the peripheral area. To judge by the channelling of the inner surface, the involution was relatively slight. Since the height of the cross-section at the posterior end is slightly over 30 mm., the rate of increase of the whorl was not rapid.

The umbilicus must have been shallow. The umbilical rim is not abruptly defined, though the surface of the flank slopes down steeply to the spiral suture. Primary ribs starting from the suture are radial in direction and are not of equal strength. At the rounded umbilical margin, some of the ribs (main ribs) swell into a rounded node, and a bifurcation of the rib may here take place, giving rise to ribs of unequal strength. Some ribs, however (intermediate ribs), do not bear umbilical nodes, and bifurcation at the nodes on the main ribs does not always take place. Some of the ribs arising from the umbilical nodes have a forward inclination as they pass towards the periphery. On the peripheral side of the middle of the flank, but near the middle, a second set of nodes is developed on the main ribs, stronger than the inner series. At these nodes a division of a rib into two or three peripheral ribs takes place, and these have a well-marked forward inclination. The intermediate ribs have a corresponding forward swing as they pass on to the periphery. The peripheral ribs are of approximately equal strength and pass across the periphery, though their development is less pronounced in the central area. This area is flat, and in better preservation might be weakly sulcate. On either side of it the ribs show traces of a swelling.

The inner surface of the fragment (that is, the concave surface) is deeply channelled, in such manner as to show that the previous whorl had a distinctly sulcate periphery, and that the central concave area was bounded on either side by a line of nodular swellings in the peripheral ribs.

*Occurrence.*—Collected at Brentford, Knysna Estuary (151h).

*Remarks.*—It is unfortunate that only a single fragment of this well-characterised form is available for study. The specimen is so imperfect that its intimate relationships cannot be precisely ascertained, and the important evidence of young and early adult growth-stages is wanting. There can scarcely be a doubt, however, that we are dealing with a representative of that group within *Hoplites* (sensu lato) to which Uhlig has given the generic name *Acanthodiscus*.\* Whether this group of trituberculate forms constitutes a generic unit may be open to question, in view of the differences in the characters of the youthful stages shown by some of its members, though

\* Uhlig (5), p. 607.

Professor Uhlig has suggested that the occurrence of cœnogenetic phenomena may account for these. So far as the characters of sculpture of this fragment are concerned, a very similar type is seen in the adult stage of *Acanthodiscus hystricoides* (Uhlig),\* from the upper Teschener Schichten of Silesia (correlated by Uhlig with the Valanginian). To judge from a comparison of such scanty material with the figures of *A. hystricoides*, the African specimen differs in the more nearly circular section of the whorl, in the occurrence of groups of three peripheral ribs arising from the outer tubercles of the flank, and perhaps also in the greater number of ribs intermediate between the main ribs. It also shows a more strong forward inclination of the ribs as they pass from the flank to the periphery.

It is impossible to say with certainty whether this form bears any close relationship to Tate's *Ammonites subanceps*, which also came from the Uitenhage beds. Tate's figured specimen † is the only one of its kind known from these beds, and it is a small individual, representing in all probability an immature stage of growth. This probability, and the great disparity in size between Tate's type and the fragment of an adult *Acanthodiscus* above described, makes a comparison difficult and unsatisfactory. The fragment here dealt with formed part of an individual exceeding 110 mm. in diameter, with an umbilical diameter, measured from the inner tubercles, of probably 45 mm. Tate's specimen measures less than 20 mm. in greatest diameter. Allowing for this, however, there is some similarity in the type of sculpture in the two forms. If they are closely related the points of distinction that exist may well be due to the fact that different stages of growth are brought into comparison. In the specimen from Knysna the sulcation of the peripheral area is very weakly marked, but it is seen from a comparison of the outer and inner sides of the whorl that this is a modification accompanying advancing growth, and that the previous whorl was much more sulcate. It is also probable that the reduction of this character is to some extent only apparent, owing to the removal of the shell-substance on the outer side by weathering. Other points in which the specimen differs from Tate's type are the presence of well-marked nodes at the umbilical margin, the situation of the second series of nodes a little nearer to the periphery, the stronger forward inclination of the peripheral ribs, and the rather broader periphery and more nearly circular outline of the whorl in cross-

\* Uhlig (2), p. 39, Taf. i., fig. 8.

† Tate (1), p. 150, pl. vii., fig. 3.



section. It should be noted with regard to the first of these points that although Tate made no mention of any trace of umbilical marginal tubercles in his specimen, such traces exist in several of the ribs, which are swollen at that part which corresponds with the row of umbilical nodes in the Knysna specimen.

While bearing in mind that these forms are so far comparable, it is at the same time not improbable that Tate's *Ammonites subanceps* should be placed with those species of *Hoplites* (sensu lato) which Uhlig has united to form the narrower generic group *Solgeria*.<sup>\*</sup> Great similarity is shown to figures of forms ascribed by Sayn † to *Hoplites arnoldi* (Pict. and Camp.) and by Toucas to *Hoplites bottellæ* Kilian.‡ These have been considered by Pavlow to be wrongly determined, and to represent one species to which he has given the name *Hoplites heteroptychus*.§ It was even suggested by Neumayr that *Ammonites subanceps* might represent the young of *Crioceras spinosissimum*, and this does not seem excluded as a possibility. While Tate's specimen, which was very imperfectly figured, is certainly to be brought into the closest comparison with Neocomian forms of *Hoplites*, and not with the Jurassic *Reineckia anceps* as thought by Tate, only the collection of additional material will show with certainty its true narrow relationships, though I am inclined to think that its nearest allies are to be sought in representatives of Uhlig's genus *Solgeria*, of which *Hoplites heteroptychus* Pavlow is an example, rather than in members of the genus *Acanthodiscus*.

## GENUS BELEMNITES Lamarck.

### BELEMNITES sp.

Two specimens of belemnites are unfortunately only of a fragmentary character. One was collected by Mr. Rogers at Brentford, Knysna Estuary (153h), and the other was obtained by Miss M. Wilman at Coega.

1. The specimen from Brentford is a fragment of a rostrum, and neither the alveolar nor apical end is preserved. It is compressed in the dorso-ventral direction in such manner as to give a broadly ovate outline in cross-section. The greatest transverse diameter is situated at some distance—at least a third of the length of the fragment—away from the alveolar end of the specimen. From this

\* Uhlig (5), p. 624.

† Sayn (1), p. 682, pl. xii., fig. 6.

‡ Toucas (1), p. 606, pl. xviii., fig. 10.

§ Pavlow and Lamplugh (1), p. 467 (109 of authors' copy).



point the outline tapers very gently, almost imperceptibly, in the alveolar direction, more markedly (though still gradually) in the apical direction. The length of the fragment is 45 mm. At the end towards the alveolus the transverse diameter is 11 mm., the dorso-ventral diameter 9.5 mm. At the other end the transverse diameter is 9 mm., the dorso-ventral measurement 8 mm. Situated on the side are two parallel, shallow longitudinal grooves, placed closely to one another. Towards the anterior end of the specimen the surface is becoming split off in the form of thin laminae.

This specimen is evidently the representative of some subfusiform species. The shape of the rostrum, though this is represented by an imperfect fragment, is sufficiently suggestive, and in addition there is the presence of the shallow parallel grooves on the side and the foliaceous character of the surface towards the alveolus. These two latter points, apart from the shape of the guard, at once recall certain *Hastati* of the European Neocomian, and there can be no doubt concerning the broad relationships of the specimen. The greatest thickness of the guard is, however, nearer to the alveolus than in *Belemnites jaculum* Phill. (= *B. subfusiformis* Rasp.), *B. pistilliformis* Blainv. (= *B. pistillirostris* Pav.), or *B. obtusirostris*.<sup>\*</sup> The outline in section is more oval and compressed than in *B. jaculum*, and although in that species there is some variation with regard to the form of the section, Mr. G. W. Lamplugh informs me that he has never observed quite such a degree of compression as is shown by the Brentford specimen.

2. The specimen from Coega is still less favourably preserved for a satisfactory comparison with known forms, but it also belongs to some subfusiform species, and one which has a rostrum of relatively slender figure. It is a fragment of a guard from which the alveolar and apical ends are missing, and is compressed in manner similar to that shown by the other specimen. It measures 46 mm. in length. The transverse diameter at the thicker end is 8 mm., the dorso-ventral diameter 7 mm. The specimen tapers gradually from here towards the thin end, where the greatest diameter is 4 mm. This end is most probably approaching the alveolus, though it shows no sign of a ventral groove. Here also the surface shows no foliaceous character, but the specimen is so unfavourably preserved and so much weathered that these negative characters are not of much significance. It is possible, however, that this thin end of the specimen lies towards the apex, but if this be the case we are dealing with a hastate form remarkable for the slow tapering towards the

<sup>\*</sup> Pavlow and Lamplugh (1), pp. 77-82.

apex. I am inclined to regard the other orientation as the correct one.

These two specimens, although so fragmentary, are of special interest. They furnish one more piece of evidence which serves to dispel the idea that the fauna of the Uitenhage beds lived under geographical conditions which prohibited free intercourse in a northerly direction. It will be remembered that a representative of the *Hastati* has been recorded from the Neocomian beds of north-west Madagascar.\* An extension of our knowledge of the belemnite-fauna in the Uitenhage deposits becomes very desirable.

## CLASS CRUSTACEA.

### GENUS MEYERIA F. M'Coy.

#### MEYERIA SCHWARZI sp. nov.

Plate VIII., fig. 22; IX., 4, 4a, 5; X., 4, 4a, 4b.

*Description.*—The elongated body shows, in its form, considerable lateral compression, and the carapace, in particular, has strong lateral flattening. The carapace, in lateral aspect, has relatively great height, and the branchiostegites occupy a large area. The cephalic portion of the carapace is best known in its posterior part, since the best-preserved specimens examined have the anterior part broken off. Commencing at the cervical suture and passing forwards there is a sharp and narrow, weakly serrated, median dorsal keel which is prolonged anteriorly into a short, sharply pointed, laterally flattened rostrum, exhibiting a median carination, weakly and finely serrated. Running almost parallel with this median keel and at a very short distance below it there is on either side a more strongly tuberculated or serrated lateral keel; at a rather greater distance below this on either side there is situated a second similar lateral keel, and, with a still greater separating space, below this there is a third lateral keel. The two lowest keels on each side have a more marked upward slope than the first lateral keel when traced forwards from the cervical groove. The surface between the keels is flat or slightly concave, and bears very little or no granular ornamentation. The appendages of the head are unknown.

The cervical suture slopes backward rather obliquely in its general course when traced upwards. In relation to the slenderly formed

\* Newton (1), p. 333.

carapace it is deeply impressed. Traced from its anterior termination, for the first few millimetres of its course, immediately under the lowest cephalic keel, it has a very slight upward inclination; it then bends more sharply upwards, and during the rest of its course, towards the median dorsal line of the carapace, it is not markedly sinuous.

Immediately behind the cervical suture there is on either side a short raised keel in backward continuation of the lowest lateral cephalic keel; this is only a few millimetres in extent (about 5 mm. in specimens examined), and immediately below it is situated a small oval area, nearly smooth, bearing only one or two isolated granules, and surrounded above and below and behind by a well-impressed linear groove. In the specimens examined this is only about 2 mm. or 3 mm. in length, but is not well defined anteriorly. From this little area the weakly developed branchial furrow passes obliquely backwards, rising gradually, and dies out before reaching the indented portion of the posterior margin of the carapace. This furrow is bounded dorsally by a slightly raised fold of the surface, which arises anteriorly at the short keel which forms the backward continuation of the lowest cephalic keel.

The median dorsal carination is a very marked feature, posteriorly to the cervical groove. Commencing at the median carina at a distance from the cervical suture of about one-third of the space between that suture and the posterior margin of the carapace, there is a very faintly marked, shallow linear groove of attenuated sigmoidal form. Meeting the corresponding groove of the opposite side in the median dorsal line so that no appreciable angle is formed by the junction, the groove on each side of the carapace forms a shorter shallow upper curve and a more extensive lower curve. Before terminating below it is for some distance directed anteriorly, and runs obliquely downwards just above the fold of the surface which accompanies the branchial furrow.

The lower margin of the thoracic part of the carapace is divisible into a shorter antero-ventral portion, which slopes gently downwards with straight outline when traced backwards, and a longer posterior portion with almost straight outline, which slopes gently upwards and then passes by a broad curve into the posterior border. The posterior border forms in its lower part a broad lobe with convex outline, and is then indented (between the branchial and cardiac regions) in the shape of a narrowly curved bay with broad opening.

The margins of the thoracic portion of the carapace are furnished



with a smooth, narrow, raised lip, which becomes somewhat broader on the posterior lobed margin of the branchiostegite, where, also, it is accompanied by a smooth, hollowed, shallow runnel of the surface. The branchiostegites are ornamented by numerous granules or minute tubercles distributed evenly over their surface. The raised folds of the surface which are situated just dorsally to the oblique branchial furrows are furnished with a row of somewhat stronger granules, besides a few granules irregularly disposed. The region of the carapace situated between the weak sigmoidal grooves (above described) and the cervical suture is ornamented by numerous granules or minute tubercles similar to those on the branchiostegite. The cardiac region, posteriorly to this, is more nearly smooth, showing only a few isolated, weakly developed granules.

The ambulatory appendages of the thoracic region are known only by a few fragments, and those actually associated with carapaces are too imperfect for accurate description. Portions of a long, slender limb occurring isolated in a nodule from the Sunday's River (the specimen is from the South African Museum collection, and bears the number 663 on a white label) may probably belong to this species. It consists of a portion of a segment of the limb, keeled, with some scattered granular ornaments and bearing a short, distally directed, lateral pointed spur, near the articulation with the succeeding (more terminal) segment. The latter is very slender and elongated and bears several longitudinal tuberculated keels.

The terga of the first five abdominal segments have a smooth surface and are narrowly and highly arched. The pleura of segments ii.-v. have a flattened or slightly convex form; they are relatively extensive and bear ornaments. The tergum of the first segment is divided across the middle by a well-marked transverse (right and left) groove. The posterior part only of this tergum is prolonged downwards to form a very small pleuron with rounded margin anteriorly, and broadly pointed below. This bears pitted ornamentation and has a transverse carination, the carinal ridge extending forwards from the point of articulation with the tubercular facet of the second segment. The surface of the pleuron below the short carina is set at a slight angle to the part above, and is flattened for movement against the posterior lobe of the branchiostegite.

The second abdominal segment is relatively broad (antero-posterior measurement), and has very large pleura which bulge forward just below the tubercular articulating facets, and have very extensive

antero-ventral margins which form a broadly convex outline. Their truncated posterior borders are slightly sinuous—being projected backwardly just below the articular socket, and having a slightly excavated outline below this. The posterior borders bear minute marginal denticles, and they form a roughly rectangular junction, below, with the antero-ventral border. There is a shallow vertical groove on the surface near the posterior border, and the pleuron also bears granular and pitted ornaments on its upper and posterior parts. Posteriorly situated, on its lower half, are two short, parallel, raised ridges bearing several minute tubercles: these have a transverse (horizontal) direction, and the lower is the shorter of the two. On the pleura of the succeeding three segments (iii.-v.) the ornaments are similar, but the horizontal tubercular ridges become reduced in size, particularly in the fifth segment. The pleura of these segments are much less extensive than those of the second segment. Those of the third and fourth segments are pointed below, with sloping, slightly convex, antero-ventral borders, with narrow smooth raised marginal lip and straight posterior borders furnished with a row of minute denticles. The pleura of the fifth segment are more broadly rounded below. Those of the sixth segment are very reduced in extent and have the posterior half of their inferior margin broadly excavated to allow of the free movement of the expanded swimming appendages of this segment. The pleura and tergum of this segment are alike ornamented with minute tubercles.

The tergum of the first abdominal segment has a shallow groove rising from the articular sockets and curving slightly forwards as it crosses the back. Similar grooves occur on the succeeding four segments, two on either side of each tergum. They arise at the (anterior) articular facet and the (posterior) articular socket and slightly converge as they pass up towards the dorsal arch of the tergum. The anterior groove on the second segment may be traced across the back, but the remaining grooves become very faintly marked or disappear on the dorsal parts. On the sixth segment, the corresponding anterior groove is very strongly marked, and passing right across the back, defines an anterior, convex, lenticular shaped tergal facet which fits under the posterior part of the fifth tergum. There is also on either side, in the posterior half of the segment, a horizontal groove, separating the pleuron from the tergum, and these pass posteriorly into a very weak shallow groove which runs across the tergal arch close to the posterior border of the segment.

The telson is relatively narrow and elongated. Its sides form

approximately straight outlines in the anterior half and converge very gradually at first, but more rapidly in the vicinity of the narrowed, rounded, posterior margin. The anterior margin is almost straightly transverse, and forms roughly rectangular junctions with the sides. The dorsal surface of the telson is of flattened form, curving down abruptly at the lateral margins. There is a weak median longitudinal ridge which dwindles away posteriorly before reaching the hinder border. At a distance of about one-quarter of the total length of the telson from its anterior border there arises from the median ridge on either side a curved, narrow ridge, bearing granules or minute tubercles. These first pass backwards, and, diverging from the median ridge, they curve outwards and pass obliquely forwards to the antero-lateral angles of the telson. Each encloses a roughly ovate area of the dorsal surface which is almost smooth, or has very sparse granular ornaments. The remainder of the surface of the telson has evenly spaced granules or minutely tubercular ornamentation.

The appendages of the abdominal segments are unknown, except portions of the expanded swimming organs of the sixth segment; but these are too imperfectly preserved for precise description.

*Dimensions.*—The largest specimen examined measures 38 mm. along the median dorsal line from the tip of the rostrum to the posterior end of the carapace. The greatest height of the carapace in this specimen, if it were perfect, would be about 16 mm. Other individuals, in which the rostral region is absent, have a similar height-measurement, and the total breadth of their carapaces measured in cross-section does not appear to exceed 8 mm., although the specimens have not suffered appreciably from lateral crushing. The length of the abdomen in extension cannot be accurately measured owing to the flexion assumed at death, but it may be estimated to have been approximately the same as that of the carapace.

*Occurrence.*—Several specimens were obtained by Mr. Rogers from a bare slope W. 30 S. from the middle of Barkly Bridge, on the farm Olifant's Kop (35h, 37h, 38h).

A specimen consisting of portions of a thoracic limb which may belong to this species is from the collection of the South African Museum and is labelled "Sunday River" (663, on white label).

*Remarks.*—Since the term "epimeron" has been used in two distinct senses by different authors, the term "pleuron" has been retained in the above description to denote the downward lateral prolongation of the tergum of each abdominal segment on either



side. The usual condition of the abdomen is one of flexion, with the pleura overlapping one another in a marked degree; but one of the specimens examined (38h) shows segments iii.-vi. so extended that the form of the pleura is well exhibited. It will be noted that the conventional terminology here used in reference to the main divisions of the body is that which is most widely known and employed.

The transverse grooves on the terga of the abdominal segments mark the degree of overlap of the segments when these are in the position of extension. The grooves probably correspond with strengthening ridges on the interior surface of the terga which pass upwards from the ball (anterior) and socket (posterior), respectively, of the lateral articulations in each segment. The depth and the dorsal continuity of the anterior groove in the sixth segment, and the smooth, convex, well-developed rolling facet anteriorly to it, which fits closely under the hinder part of the fifth tergum, appear to be contrivances for securing the rigidity and strength called for in the exercise of rapid and vigorous movements of the tail in swimming or springing. The tergal facets of the preceding segments are much less well developed and defined.

*Meyeria schwarzi* differs widely from *M. ornata* (Phill.),\* from the Speeton Clay, in the absence of the characteristic ornaments on the abdominal terga and in the form of the pleura, as well as in other features. From *M. magna* M'Coy [= *M. vectensis* Bell],† of the Aptian of the Isle of Wight, it is readily separable by the absence of ornamenting granular ridges on the abdominal terga, by the weaker development and different position of the oblique branchial fold or carina, and by the form of the pleura. *M. magna* also appears to be a much larger and more robustly formed species. It may be remarked that the fragment of an elongated ambulatory leg (South African Museum collection, No. 663), mentioned above, bears much resemblance, in its relative proportions and in its tuberculated ornamenting keels, to the long and slender anterior thoracic legs of *M. magna*.‡

There appears to be very considerable resemblance between *M. schwarzi* and *M. rapax* Harbort,§ from the Lower Valanginian of North Germany. Both have a smooth surface in the abdominal terga i.-v., and the form and ornamentation of the pleura are very

\* Bell (1), p. 33, pl. ix., figs. 9-11.

† M'Coy (1), p. 334; Bell (1), p. 33, pl. x.

‡ Bell (1), pl. x., figs. 1, 4.

§ Harbort (1), p. 11, Taf. i., fig. 12; ii., figs. 1-4; iii., figs. 1, 2; xi., figs. 1, 2.

similar. *M. rapax*, however, attained much larger dimensions and more robust form than any of the specimens of *M. schwarzi* examined, and it appears also from Dr. Harbort's figures that the cephalothorax of his species has less relative lateral compression. Other differences that may be noticed are as follows. In *M. rapax* the development of the obliquely running blunt branchial keel is much more pronounced; the anterior margins of the abdominal pleura are denticulated; the sixth abdominal segment has greater lateral depth and is not so depressed dorsally as the corresponding segment in *M. schwarzi*. Further, Dr. Harbort makes no mention of distinctive ornaments on the telson such as those which characterise the African form. The little smooth oval area at the anterior end of the branchial groove, which is well marked in *M. schwarzi*, does not appear to be an evident feature in *M. rapax*, if developed at all, and the same may be said of the grooves of attenuated sigmoidal form in front of the cardiac region of the carapace.

With reference to the above-mentioned small, smooth, oval area, which is situated on either side of the carapace on the anterior part of the branchiostegite, this structure is well represented also in *Meyeria magna* M'Coy, but does not seem to have attracted special attention. Its significance is not obvious, but it appears to be homologous with the similar areas on the carapace of *Pseudoglyphæa*. These were considered by Oppel to be a constant characteristic of that genus,\* and he referred to them as "reniform eminences," but did not enter into the question of their meaning. Corresponding structures of modified form may also be seen in some species of *Glyphæa*.

#### (A). LISTS OF THE FOSSILS CRITICALLY EXAMINED.

The lists of fossils collected by Messrs. Rogers and Schwarz in 1900 and by Mr. Rogers in 1905 should be read in connection with the published official reports by these authors, which contain the records of additional forms seen by the Surveyors to occur at some of the localities. Thus, for instance, in the first report, among the fossils stated to have been found in the Marine Beds at Grass Ridge, near Uitenhage, there are the names of ten Mollusca, specimens of which were not brought away.† In the later report by Mr. Rogers, many fossils are in like manner recorded, which are not represented in the collections submitted for examination.‡

\* Oppel (1), p. 51.

† Rogers and Schwarz (1), p. 9.

‡ Rogers (2).



(1) ZWARTKOP'S RIVER.

(Specimens collected by Messrs. Rogers and Schwarz, 1900.)

a. Railway cutting between milestones  $24\frac{1}{2}$ – $24\frac{3}{4}$  on the railway from Uitenhage to Graaff-Reinet, about 3 miles from Uitenhage.

<i>Thamnastraea</i> sp. ....	(345, 346, 347, 348, 349)
<i>Serpula</i> cf. <i>concava</i> (J. Sow.) .....	(332)
<i>Pecten</i> ( <i>Camptonectes</i> ) <i>projectus</i> Tate .....	(297, 350)
<i>Lima</i> ( <i>Acesta</i> ) <i>obliquissima</i> Tate .....	(346)
<i>Exogyra</i> <i>imbricata</i> Krauss .....	(312)
<i>Trigonia</i> <i>conocardiiformis</i> (Krauss) ...	(297, 298)
„ <i>vau</i> ? Sharpe .....	(309)
<i>Cyprina</i> <i>borcherdsi</i> Tate.....	(313)
<i>Thetironia</i> <i>papyracea</i> (Sharpe) .....	(315)
<i>Meretrix</i> <i>uitenhagensis</i> sp. nov. ....	(316)
<i>Thracia</i> sp. ....	(331)
<i>Natica</i> <i>uitenhagensis</i> ? sp. nov.....	(314, 350)
<i>Holcostephanus</i> <i>uitenhagensis</i> sp. nov.	(276)

b. Grass Ridge, 3 miles east-north-east of Uitenhage.

<i>Trigonia</i> <i>tatei</i> Neumayr .....	(335)
<i>Trapezium</i> ? <i>tatei</i> sp. nov. ....	(310)
<i>Meretrix</i> <i>uitenhagensis</i> sp. nov. ....	(310)
<i>Solecurtus</i> sp. ....	(310)
<i>Pleuromya</i> <i>baini</i> (Sharpe) .....	(317, 318, 334, 335)
<i>Actæonina</i> <i>atherstoni</i> (Sharpe) .....	(333)

c. Krantz near Picnic Bush, north-east of Red House.

<i>Astarte</i> ( <i>Eriphyla</i> ) <i>herzogi</i> (Goldf.) .....	(328)
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d. Kloof on the left side of Zwartkop's River, east-north-east of Red House.

<i>Trigonia</i> <i>ventricosa</i> (Krauss) .....	(308)
<i>Astarte</i> ( <i>Eriphyla</i> ) <i>herzogi</i> (Goldf.) .....	(326, 327)
<i>Tancredia</i> <i>schwarzi</i> sp. nov. ....	(324)
<i>Meretrix</i> <i>uitenhagensis</i> sp. nov.....	(324)



- e. Road below railway cutting, 1 mile from Rawson Bridge on the main line, up side.

*Bochianites glaber* sp. nov. .... (277, 338)

- f. Clay-pit on the left bank of Zwartkop's River near Rawson Bridge.

*Actæonina atherstoni* (Sharpe) ..... (343)

*Bochianites* ? ..... (278, 339, 344)

- g. One mile north-east of Rawson Bridge.

*Modiola baini* Sharpe ..... (281)

## (2) BEZUIDENHOUT'S RIVER.

(Collected by Messrs. Rogers and Schwarz, 1900.)

*Unio uitenhagensis* sp. nov. .... (322, 323)

## (3) SUNDAY'S RIVER.

(Collected by Messrs. Rogers and Schwarz, 1900.)

- a. Cliff below the old school-house on the right bank of Sunday's River, Dunbrodie (Geelhoutboom).

*Pecten* (*Camptonectes*) *cottaldinus* d'Orb. (305, 306)

*Perna atherstoni* Sharpe ..... (305)

*Ostrea* sp. .... (305, 306, 336)

*Mytilus uitenhagensis* sp. nov. .... (319)

*Cyprina rugulosa* Sharpe ..... (325)

*Psammobia atherstoni* Sharpe ..... (321)

*Gastrochæna dominicalis* Sharpe ..... (336)

*Turbo atherstoni* Sharpe ..... (351)

„ *rogersi* sp. nov. .... (282)

„ *minutulus* sp. nov. .... (305, 351)

„ *sp.* ..... (351)

*Actæonina atherstoni* (Sharpe) ..... (283, 284)

- b. Walton's Farm, below Dunbrodie.

*Perna atherstoni* Sharpe ..... (311)

*Trigonia stowi* ? sp. nov. .... (307)

(Collected by Mr. A. W. Rogers, 1905.)

c. Cliff on Buck Kraal.

<i>Serpula pinchiniana</i> Tate .....	(122h)
<i>Trigonia herzegi</i> (Goldf.).....	(116h, 120h, 122h)
<i>Cyprina rugulosa</i> Sharpe .....	(128h)
<i>Mactra?</i> <i>dubia</i> sp. nov. ....	(141h)
<i>Natica?</i> <i>mirifica</i> sp. nov. ....	(137h)
<i>Natica rogersi</i> sp. nov.....	(136h)
<i>Limnæa remota</i> sp. nov. ....	(138h)

d. Cliff on the right bank of Sunday's River on Commando Kraal.

<i>Trigonia conocardiiformis</i> (Krauss).....	(104h)
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e. 300 yards below Addo Drift (Tunbridge's), left bank of Sunday's River.

<i>Trigonia vau</i> Sharpe.....	(40h, 41h, 42h, 46h)
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f. Cliff on Zoet Geneugd.

<i>Trigonia conocardiiformis</i> (Krauss)	(67h), from higher beds.
„ <i>herzegi</i> (Goldf.) .....	(99h).
<i>Mytilus uitenhagensis</i> sp. nov. ....	(64h), from lowest beds.

g. Kloof S. 5 W. from Comley's House, right bank of Sunday's River.

<i>Thetironia oblonga</i> sp. nov. ....	(83h)
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h. Nek S. 32 E. from Comley's House, right bank of Sunday's River.

<i>Trigonia conocardiiformis</i> (Krauss) .....	(86h)
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i. Cliff W. 20 S. from Comley's House.

<i>Trigonia stowi</i> sp. nov. ....	(90h)
<i>Tancredia schwarzi</i> sp. nov. ....	(95h)
<i>Turbo atherstoni</i> Sharpe.....	(95h)
<i>Natica?</i> <i>mirifica</i> sp. nov. ....	(95h)
<i>Actæonina atherstoni</i> (Sharpe) .....	(92h)
„ <i>cf. atherstoni</i> (Sharpe).....	(95h)



j. Bare slope W. 30 S. from the middle of Barkly Bridge, on the farm Olifant's Kop.

<i>Trigonia conocardiiformis</i> (Krauss)	(21h)
„ <i>rogersi</i> sp. nov. ....	(20h)
<i>Astarte</i> sp. ....	(24h)
<i>Anthonya lineata</i> sp. nov. ....	(35h)
<i>Meretrix uitenhagensis</i> sp. nov. ...	(24h, 26h, 28h, 29h, 30h)
<i>Actæonina atherstoni</i> (Sharpe) ...	(24h)
<i>Meyeria schwarzi</i> sp. nov. ....	(35h, 37h, 38h)

k. Kloof behind Colchester.

<i>Meretrix uitenhagensis</i> sp. nov.	(493g, 498g) from highest beds.
<i>Pleuromya baini</i> (Sharpe) ...	(495g) „ „
<i>Goniomya</i> sp. ....	(489g) „ „
<i>Actæonina atherstoni</i> (Sharpe)	(499g) „ „
<i>Phylloceras rogersi</i> sp. nov. ...	(3h) from middle beds.

l. Small kloof 3 miles up the left bank of Sunday's River.

<i>Trigonia stowi</i> sp. nov. ....	(17h)
„ <i>ventricosa</i> (Krauss) ....	(14h, 15h)

The following list is based upon specimens, in the collection of the South African Museum, from Sunday's River :—

<i>Serpula pinchiniana</i> Tate .....	(303)
<i>Pecten</i> ( <i>Syncyclonema</i> ) <i>orbicularis</i> J. Sow.	(279, 280)
„ ( <i>Chlamys</i> ) cf. <i>subacutus</i> Lam. ....	(304)
<i>Lima</i> ( <i>Acesta</i> ) <i>obliquissima</i> Tate	
<i>Exogyra imbricata</i> Krauss .....	(300, 301, 302, 303)
<i>Trigonia herzogi</i> (Goldf.) .....	(289)
„ <i>holubi</i> sp. nov. ....	(285, 286, 287, 288, 290, 291, 292, 293, 294, 295, 296, 299)
„ <i>vau</i> Sharpe	
„ <i>conocardiiformis</i> (Krauss)	
<i>Tancredia schwarzi</i> sp. nov.	
<i>Meretrix uitenhagensis</i> sp. nov.	
<i>Actæonina atherstoni</i> (Sharpe)	
<i>Holcostephanus</i> cf. <i>atherstoni</i> (Sharpe)	
„ <i>rogersi</i> sp. nov.	



Specimens of the following, in the South African Museum, are also believed to have come from the Sunday's River :—

- Trigonia kraussi* sp. nov.  
 „ *stowi* sp. nov.  
*Holcostephanus atherstoni* (Sharpe)  
 „ cf. *baini* (Sharpe)

Specimens from Sunday's River, in the collection of the Geological Society of London :—

- Holcostephanus baini* (Sharpe)  
 „ *modderensis* sp. nov. (Modder Drift)  
 „ *wilmanæ* sp. nov. ... (Aasvogel Krantz, above Modder Drift. Specimen numbered 10975A.)

#### (4) COEGA RIVER.

(Collected by Mr. A. W. Rogers, 1905.)

- a. Wash-out 100 feet above Coega station at a point one mile north of Coega Hotel.

<i>Nucula uitenhagensis</i> sp. nov. ....	(441g)
<i>Trigonia</i> sp. ....	(438g)

- b. From valley east of railway, 1 mile up the line from Coega station.

<i>Mytilus uitenhagensis</i> sp. nov. ....	(479g)
<i>Trigonia herzogi</i> (Goldf.) ....	(474g)
„ <i>rogersi</i> sp. nov. ....	(472g)
<i>Astarte longlandsiana</i> Tate ....	(477g)

- c. Left side of Coega Valley, half a mile down from the railway.

<i>Serpula pinchiniana</i> Tate ....	(458g)
<i>Pecten orbicularis</i> J. Sow. ....	(453g)
<i>Lima (Acesta) obliquissima</i> Tate ....	(455g)
„ ( <i>Mantellum</i> ) <i>neglecta</i> Tate ....	(448g, 449g, 453g)
<i>Trigonia holubi</i> sp. nov. ....	(458g)
„ <i>ventricosa</i> (Krauss) ....	(463g)
<i>Cardita nuculoides</i> Tate. ....	(466g)

<i>Anthonya lineata</i> sp. nov. ....	(461g)
<i>Cyprina borcherdsi</i> Tate.....	(467g)
<i>Trapezium ? tatei</i> sp. nov. ....	(452g)
<i>Meretrix uitenhagensis</i> sp. nov.....	(453g, 454g)

d. Left side of Coega Valley, 2 miles down from the railway.

<i>Trigonia herzogi</i> (Goldf.) .....	(468g)
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(Collected by Miss M. Wilman.)

e. Coega River.

<i>Astarte (Eriphyla) pinchiniana</i> Tate
<i>Pecten (Camptonectes) projectus</i> Tate

f. Coega.

<i>Exogyra imbricata</i> Krauss
<i>Grammatodon jonesi</i> (Tate)
<i>Thetironia papyracea</i> (Sharpe)
<i>Pleurotomaria</i> sp.
<i>Holcostephanus atherstoni</i> (Sharpe)
<i>Belemnites</i> sp.

The following are in the collection of the South African Museum, from Coega :—

<i>Exogyra imbricata</i> Krauss
<i>Patella caperata</i> Tate

#### (5) KNYSNA.

(Collected by Mr. A. W. Rogers, 1905.)

Brentford, Knysna Estuary.

<i>Trigonia holubi ?</i> sp. nov. [young individual] .....	(150h)
<i>Acanthodiscus</i> sp. ....	(151h)
<i>Belemnites</i> sp.....	(153h)

The names of all the fossils mentioned above are brought together in a synoptic list at the end of the following Section (VI.) of this memoir.



(B). LIST OF INVERTEBRATE FOSSILS FROM THE UITENHAGE SERIES, NOT REPRESENTED IN THE COLLECTIONS EXAMINED.

<i>Isastræa antipodum</i> Tate	* <i>Ptychomya complicata</i> (Tate)
<i>Cidaris pustulifera</i> Tate	<i>Cyrena ? baini</i> Sharpe
* <i>Serpula</i> sp. (two species)	<i>Trapezium nivenianum</i> (Tate)
* <i>Berenicea antipodum</i> Tate	<i>Pleuromya lutraria</i> (Krauss)
<i>Pteria baini</i> (Sharpe)	* <i>Pholadomya dominicalis</i> Sharpe
* <i>Pecten rubidgeanus</i> Tate	<i>Corbula ? rockiana</i> Tate
* <i>Gervillia dentata</i> Krauss	<i>Trochus baini</i> Sharpe
* <i>Pinna sharpei</i> Tate	<i>Monodonta hausmanni</i> Neum.
* <i>Placunopsis imbricata</i> Tate	<i>Neritopsis ? turbinata</i> Sharpe
* „ <i>subjurensis</i> Tate	<i>Natica atherstoni</i> Sharpe
„ <i>undulata</i> Tate	<i>Turritella rubidgeana</i> Tate
* <i>Exogyra jonesiana</i> Tate	<i>Alaria coronata</i> Tate
<i>Mytilus jonesi</i> Tate	<i>Nautilus</i> sp.
<i>Modiola atherstoni</i> Sharpe	<i>Hamites africanus</i> Tate
„ <i>rubidgei</i> Tate	* <i>Hoplites subanceps</i> (Tate)
<i>Lithodomus stowianus</i> Tate	<i>Crioceras spinosissimum</i> (Hausm.)
<i>Cucullæa kraussi</i> Tate	Neum.
<i>Grammatodon atherstoni</i> (Sharpe)	<i>Belemnites africanus</i> Tate
<i>Seebachia bronni</i> (Krauss)	

The above list is given as far as possible with corrected nomenclature, but some of the names are still subject to revision, though in nearly all instances I have been able to see either the original types or other satisfactory specimens. In the case of *Pinna sharpei* no specimen was seen by Tate, and the species was founded upon a drawing made by Stow from a specimen collected by another geologist. The names marked with an asterisk have received some brief mention in the second section of this paper.

In addition to the above, the following forms have also been recorded from the Uitenhage beds:—

*Sanguinolaria ? africana* Sharpe  
*Turbo stowianus* Tate  
*Phasianella ? sharpei* Tate  
*Chemnitzia africana* Tate  
*Ampullaria ? ignobilis* Tate  
*Actæonina jenkinsiana* Tate  
 „ *morrisiana* Tate  
 „ *sharpeana* Tate



The materials upon which these names are based are for the most part unsatisfactory, and in several cases consist of small shells which were figured by Sharpe, though considered by him to be unfitted for specific determination. *Sanguinolaria ? africana* is a small shell of doubtful generic position, and the species may perhaps be founded upon an immature individual. *Turbo stowianus* has never been figured, and I have not been able to find the specimens described by Tate. *Phasianella ? sharpei* is a minute shell, and its generic position cannot be determined. *Chemnitzia africana*, founded upon a single individual, has not been figured, and I have not found the type-specimen. *Ampullaria ? ignobilis* is the name given by Tate to a very small shell figured by Sharpe, but the specimen cannot be found and its generic position is quite uncertain. The three forms ascribed by Tate to *Actæonina* are represented by specimens of minute dimensions figured by Sharpe. These determinations, like those above mentioned, are quite unsatisfactory; the specimens are probably immature, and in any case it is evident that more than a single genus is represented.

A comparison of the names of the Mollusca in all the above lists with those in the list given by Mr. R. B. Newton in 1896\* shows an apparent want of agreement in some few items, and for convenience of reference these may be briefly noted here. *Reineckia subanceps* of Mr. Newton's list is the shell I have referred to *Hoplites*. In place of *Actæon* (for *A. atherstoni*) I have been led to use *Actæonina*, since the shells in question show no trace of plication on the columella; it has also been possible to show that *Turbo baini* must now be considered as a synonym of *Turbo atherstoni*. To substitute the name *Turbonilla* in place of Tate's *Chemnitzia* must be regarded as hazardous in view of the fact that the original determination was unsatisfactorily established. In place of *Cyprina*, Mr. Newton used *Arctica*, a name which is unfortunately preoccupied, even were there any valid objection to the employment of the familiar and long-established name *Cyprina*. *Ceromya papyracea* is now shown to be referable to *Thetironia*. Tate's *Crassatella complicata*, as pointed out by previous writers, belongs to the genus *Ptychomya*, and the emendation to *Crassatellites* is therefore incorrect. *Cucullæa cancellata* in Mr. Newton's list is a synonym of *Cucullæa kraussi* Tate, and was no doubt retained through oversight. In the case of *Cucullæa ? jonesi* and *Parallelodon atherstoni*, which may be

\* Newton (2), pp. 150, 151.

referred to a single genus, I have employed the name *Grammatodon*. The selection of a correct name for these and similar Mesozoic forms might possibly be regarded as still debatable, but in this matter I have deferred to the opinion of Mr. H. Woods—a view with which Dr. Wheelton Hind is now also in agreement. In the choice between the generic names *Gari* and *Psammobia* opinions are divided, but I have given reasons for preferring to retain *Psammobia* (for *Ps. atherstoni*), although this course cannot perhaps be strictly justified, except as a measure of expediency to meet the circumstances of this particular instance. In the case of *Avicula baini*, the generic name *Pteria*, which has the prior claim, is used in one of the above lists. *Gryphæa imbricata* we have seen to be more correctly referable to *Exogyra*, to which it was originally assigned by Krauss, and I have pointed out that there is no foundation whatever for the inclusion of the name *Trigonia goldfussi* in any list of molluscs from the Uitenhage Series.

It should be remarked that the errors to which some of the discrepancies above noted are due, are such as must almost inevitably occur in a list of fossils which is compiled from previous works, with attempt at revision, without the examination of actual specimens, even though the task of compilation be carried out as carefully as in Mr. Newton's paper.

## VI.—SUMMARY.\*

*General Results.*—The great majority of the invertebrate fossils collected from the Uitenhage Beds consist of marine Mollusca, and have been obtained from localities in the valleys of the Sunday's, Zwartkop's, and Coega Rivers. The present study has shown that these marine fossils in reality furnish evidence which enables us to estimate their geological age with considerable precision. A more detailed examination of the fauna than that undertaken by Neumayr fully corroborates that author's conclusion that a large number of the Mollusca show affinity to Cretaceous rather than to Jurassic forms. The broad question of age which has given rise to such widely different expressions of opinion is, in fact, decisively answered by the occurrence of representatives of the following genera: *Holcostephanus* (sensu stricto); *Hamites*; *Crioceras*; *Bochianites*; *Acanthodiscus*; *Trigonia* (divisions *Scabræ* and *Pseudo-quadratæ*);

\* See also Kitchin (2).



*Ptychomya*; *Thetironia*; *Anthonya*; *Solecirtus*, and *Meyeria*. Further, there is found to be no support whatever for the suggestion occasionally put forth, that the Uitenhage Marine Beds may correspond to a part of both the Upper Jurassic and the Lower Cretaceous series of Europe. So far as the palæontological evidence goes, there appears to be every probability that the strata yielding the marine fossils were deposited with comparatively great rapidity, and there is no indication of such diversity in the character of the fauna as would be consistent with the supposition that more than the equivalent of one palæontological stage is represented. Some of the typical marine forms are now known to have a much more extensive vertical range in the series than was formerly suspected, and the sameness of character in the fauna observed at different levels in the series seems to preclude any attempt to establish zonal divisions. It may be inferred that the Marine Beds were rapidly accumulated, and that they represent a very restricted period of time.

Amongst the Uitenhage Mollusca, the Gasteropoda constitute the least important element in a comparative study, while the Cephalopoda furnish the most significant evidence by reason of their close alliance with forms having well-restricted vertical range in Europe. The Lamellibranchiata largely preponderate in the fauna, and prominent amongst these are *Trigonia* which represent divisions of the genus as yet unknown to occur in Europe. While many of the lamellibranchs afford data which are valuable in supporting the evidence yielded by the Cephalopoda, in a correlation with European standards, some of the best-characterised bivalves are of very great interest from the fact that they and their close allies have an extensive geographical distribution, and enable us to bring the Uitenhage Series into broad correlation with deposits situated in widely separated regions outside the European area.

*Correlation of the Fauna.*—A detailed comparison with the Secondary faunas of Europe has shown that, despite the presence of some few bivalve forms which not remotely resemble familiar Jurassic types, there is abundant evidence in support of the opinion of those German writers who have ascribed to the Uitenhage Series a Lower Cretaceous age. Only a very small proportion of the Mollusca can be definitely identified with European forms, but a considerable number are closely comparable with Neocomian and Aptian shells. This is true of many of the lamellibranchs, which nevertheless, as might be expected, would alone afford comparatively scanty data for a precise correlation of the Uitenhage beds with members of the



Lower Cretaceous series in Europe. A surer guide may be recognised in some of the Cephalopoda, more especially in the representatives of *Holcostephanus* (sensu stricto) which so preponderate in the Uitenhage cephalopod-fauna. It is obvious that these have very near allies in Europe which are confined to the Upper Valanginian and Lower Hauterivian, and this fact may suffice to justify the provisional approximate correlation of the Marine Beds with this part of the Neocomian.

In the attempt to trace relationships between the Uitenhage molluscs and those of Lower Cretaceous deposits in extra-European regions, the desirable evidence to be derived from a comparison of cephalopod-types is as yet not forthcoming, if we except the single case of *Holcostephanus schenki* (Oppel), from the Spiti Shales, which is closely allied to some of the South African *Holcostephani*. Certain well-characterised lamellibranchs, on the other hand, some of which are of a very specialised nature, point to the bonds by which this development of the Neocomian in Cape Colony is connected with the Oomia *Trigonia*-beds of Cutch, the strata yielding *Trigonia ventricosa* in the Godavari district and in Hazara (Himalayas), the Neocomian deposits of German East Africa, and the Lower Cretaceous strata of presumably like age in Chili, Bolivia, and the Argentine Republic. In comparing the faunas, importance must be attached to the evidence of some of the *Trigoniæ*, notably of the divisions *Scabræ* and *Pseudo-quadrata*. In particular, the points of contact revealed by a comparison of the lamellibranch-fauna of the Uitenhage Series with that of the Oomia *Trigonia*-beds are found to be very remarkable, and of such a kind that we must infer the approximate contemporaneity of these two faunas, and the existence of facilities for intercourse between the two areas. It becomes, therefore, a matter for some surprise that the Uitenhage ammonitoids or forms closely allied to them are as yet unknown in Cutch, and the real or apparent absence of such forms from the Neocomian deposits of German East Africa and of South America is also a striking circumstance.

*The Relation of the Fauna to some Questions of Distribution.*—A careful comparative study of the Uitenhage Mollusca dispels the idea, emphasised by Neumayr, that this fauna proclaims its isolated position by the sharp contrast it affords to the comparable faunas of other regions, and that it may therefore be considered to support the theory of an Indo-African land barrier in early Cretaceous times. Neumayr laid principal stress upon the contrast between the fauna of the Neocomian Belemnite-beds in the north-west of Madagascar

and that of the Uitenhage Series. It is probable, however, that this contrast may be due to a difference of facies, and in any case the argument derivable from it is greatly weakened, if not rendered valueless, by the relation seen to exist between the Uitenhage molluscan assemblage and that of the more truly comparable faunas in East Africa and Cutch. There are other facts also which are known to cast doubt upon the existence of an effective barrier to migration between the equatorial and southern waters to the east of the African continent, in Cretaceous times.

Neumayr laid great stress upon the occurrence of *Belemnites africanus* in the Uitenhage Series in support of his theory of the distribution of cephalopods according to climatic zones. He found this form to belong to a group which, though occurring in the colder waters of the northern hemisphere, appeared to have no representatives in the warmer equatorial regions. While the known distribution of *Holcostephanus* (sensu stricto) might at first thought be considered to support in a similar manner the broad principle laid down by Neumayr, it would certainly not be justifiable to attach any such significance to the facts. Our knowledge is as yet very incomplete, but a body of evidence relating to the distribution of fossil Cephalopoda has now been accumulated, which casts the strongest possible doubts upon the soundness of Neumayr's theory. Hence it will be well to exercise the greatest caution in the attempt to estimate the significance of the Uitenhage Cephalopoda in any general question of distribution. The apparent absence of identical or closely related forms from the Neocomian rocks of German East Africa and of Cutch is in all probability owing either to our imperfect acquaintance with the fossil faunas in these districts, or to conditions of a local nature which may really have determined the absence of such forms, in manner not unknown among the Cephalopoda of various geological horizons within restricted areas in Europe.

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LIST OF THE FOSSILS COMPRISED IN THE COLLECTIONS  
SPECIALLY DEALT WITH IN THE FOREGOING PAGES.

The genera and species are arranged alphabetically under their respective classes. Their arrangement under localities is set forth in the lists at the end of the previous section of this memoir.

ANTHOZOA.

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<i>Thamnastræa</i> sp. ....	62

ANNELIDA.

<i>Serpula</i> cf. <i>concava</i> (J. Sow.) .....	63
„ <i>pinchiniana</i> Tate .....	64

LAMELLIBRANCHIATA.

<i>Anthonya lineata</i> sp. nov. ....	137
<i>Astarte</i> ( <i>Eriphyla</i> ) <i>herzogi</i> (Goldf.) .....	128
„ <i>longlandsiana</i> Tate .....	128
„ ( <i>Eriphyla</i> ) <i>pinchiniana</i> Tate .....	135
<i>Cardita nuculoides</i> Tate.....	127
<i>Cyprina borchersdi</i> Tate .....	150
„ <i>rugulosa</i> Sharpe .....	149
<i>Exogyra imbricata</i> Krauss .....	77
<i>Gastrochæna dominicalis</i> Sharpe .....	162
<i>Goniomya</i> sp. ....	159
<i>Grammatodon jonesi</i> (Tate) .....	88
<i>Lima</i> ( <i>Mantellum</i> ) <i>neglecta</i> Tate .....	74
„ ( <i>Acesta</i> ) <i>obliquissima</i> Tate .....	71
<i>Mactra</i> ? <i>dubia</i> sp. nov.....	156
<i>Meretrix uitenhagensis</i> sp. nov. ....	151
<i>Modiola baini</i> Sharpe.....	85
<i>Mytilus uitenhagensis</i> sp. nov. ....	82
<i>Nucula uitenhagensis</i> sp. nov. ....	87
<i>Ostrea</i> sp. ....	77
<i>Pecten</i> ( <i>Camptonectes</i> ) <i>cottaldinus</i> d'Orb. ....	65
„ ( <i>Syncyclonema</i> ) <i>orbicularis</i> J. Sow .....	65
„ ( <i>Camptonectes</i> ) <i>projectus</i> Tate .....	66
„ ( <i>Chlamys</i> ) cf. <i>subacutus</i> Lam. ....	69
<i>Perna atherstoni</i> Sharpe .....	75
<i>Pinna atherstoni</i> Sharpe .....	76



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<i>Pleuromya bairni</i> (Sharpe) .....	157
<i>Psammobia atherstoni</i> Sharpe .....	154
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- (5) Handbuch der Palæontologie, Band ii., 1881-85.

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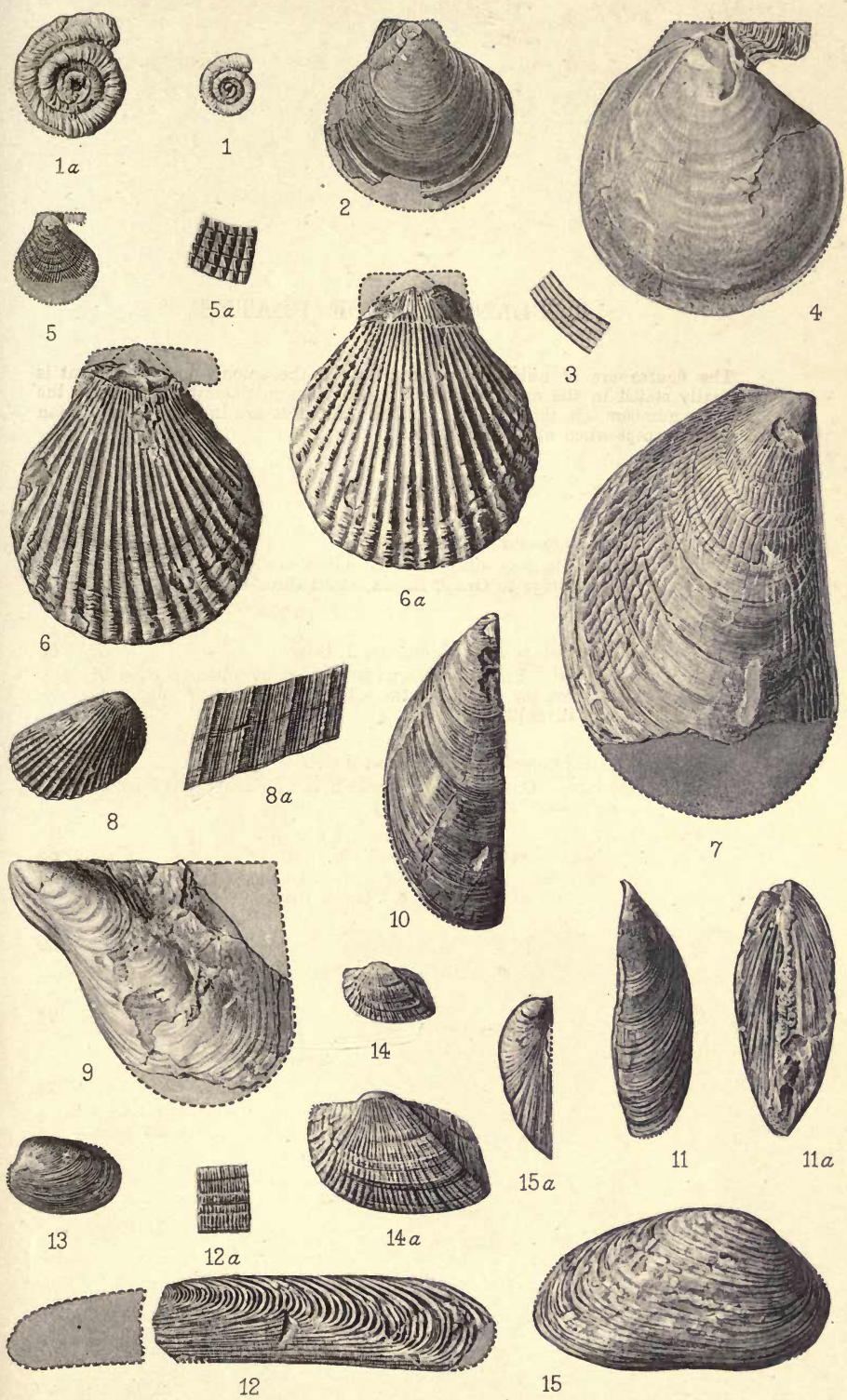
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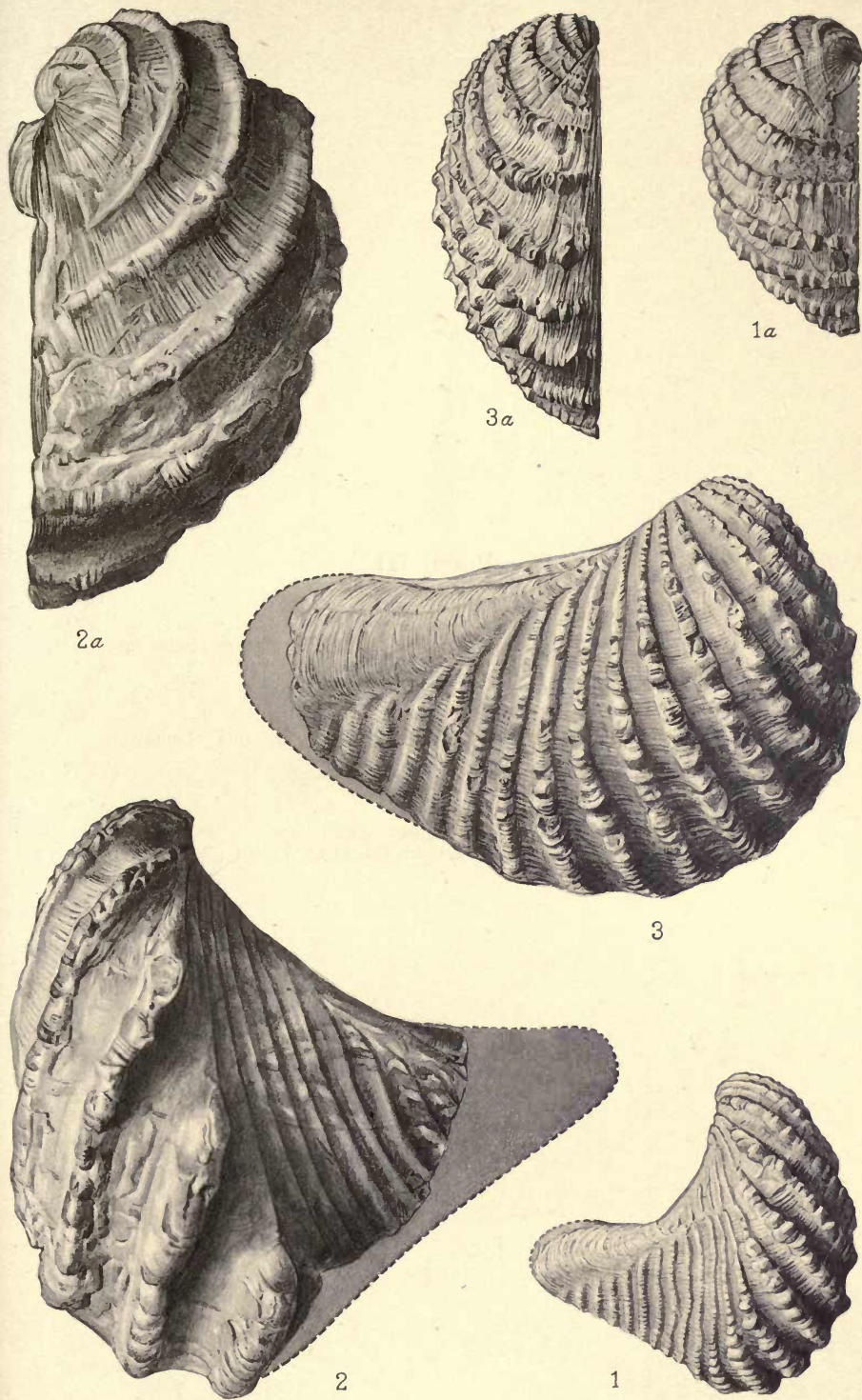
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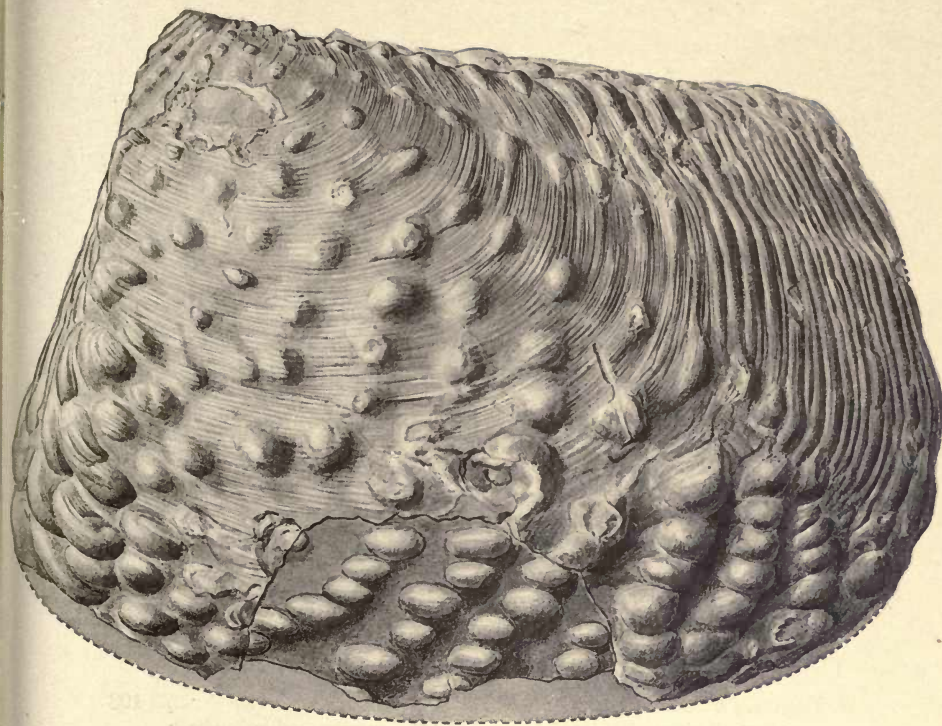




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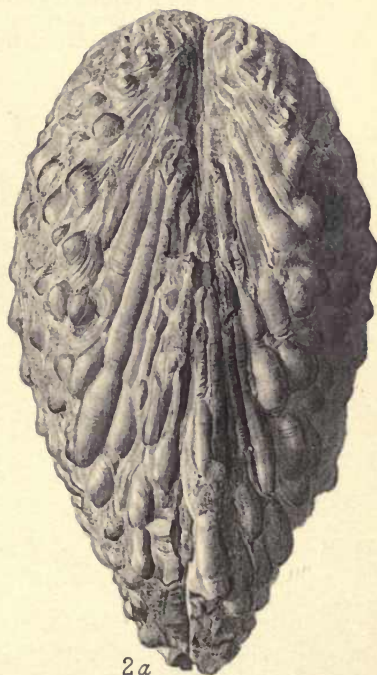




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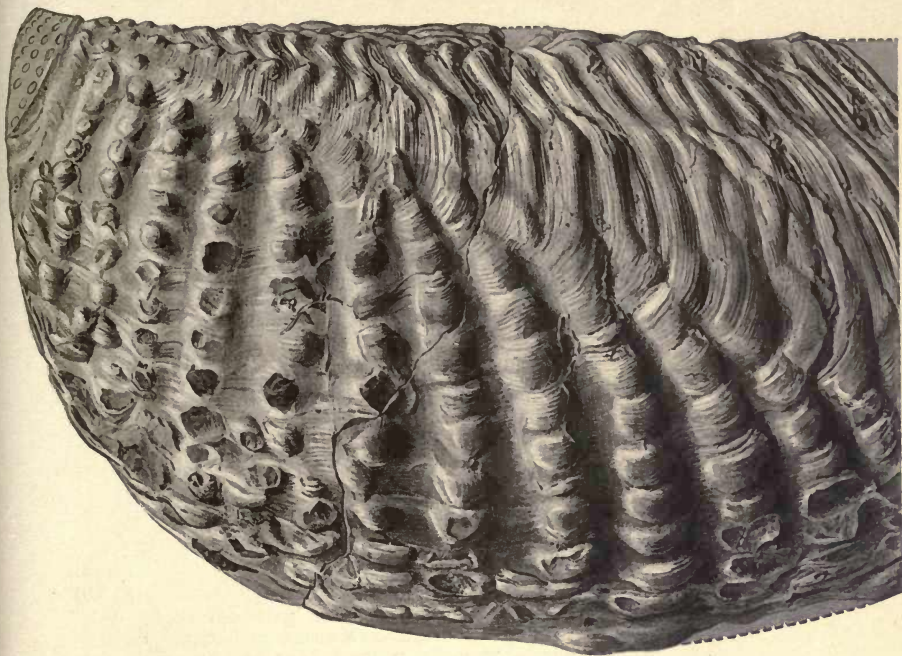
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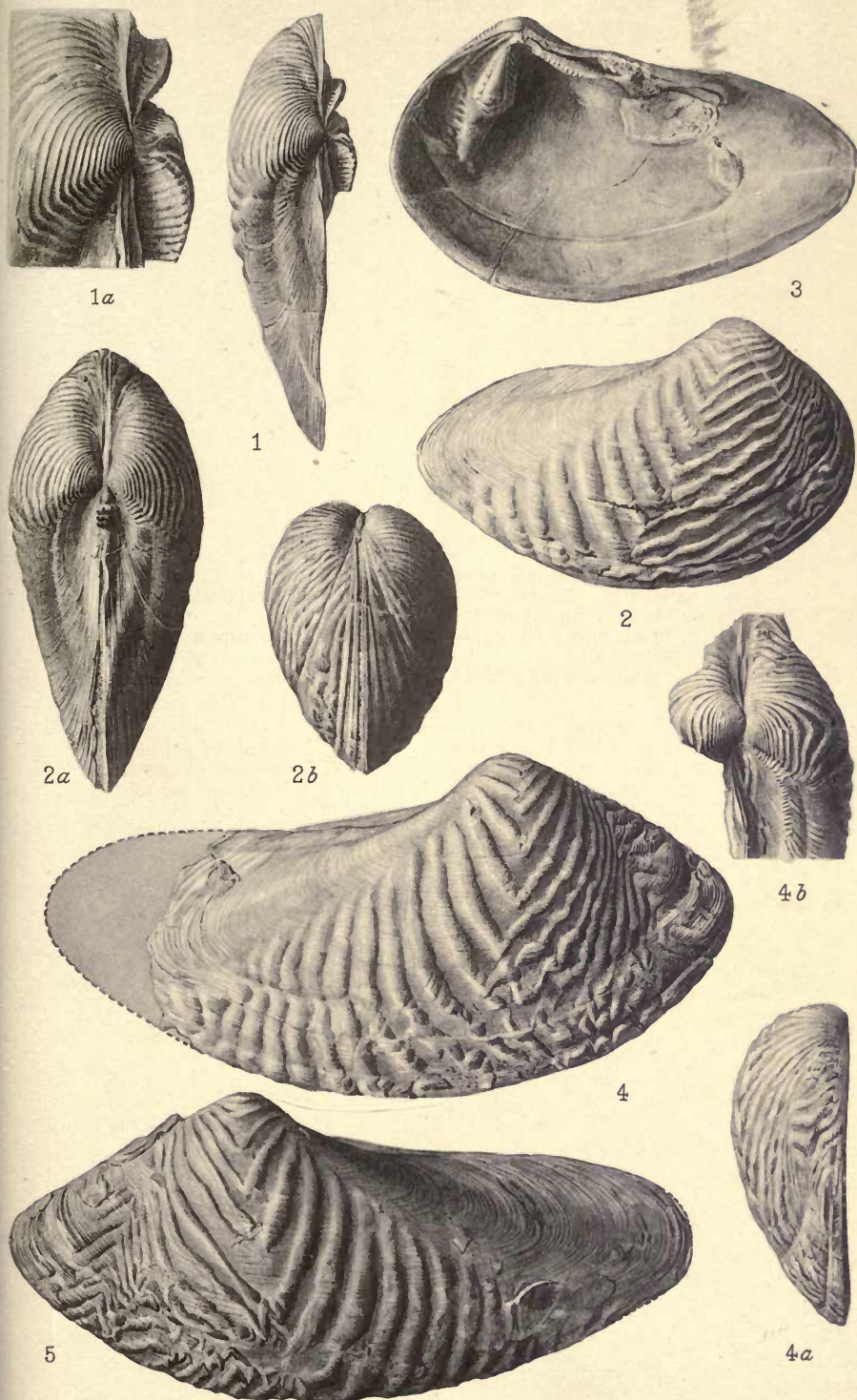






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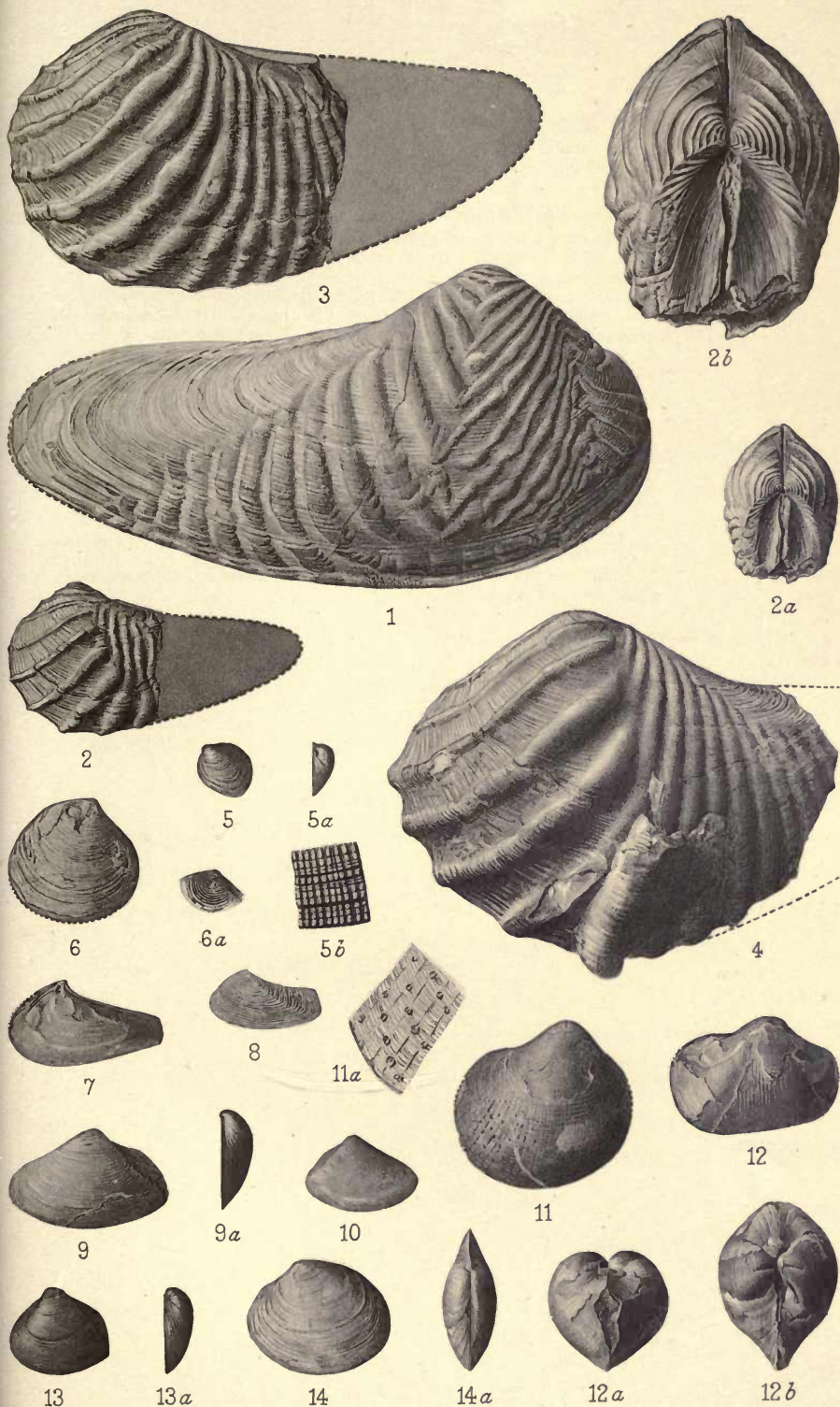




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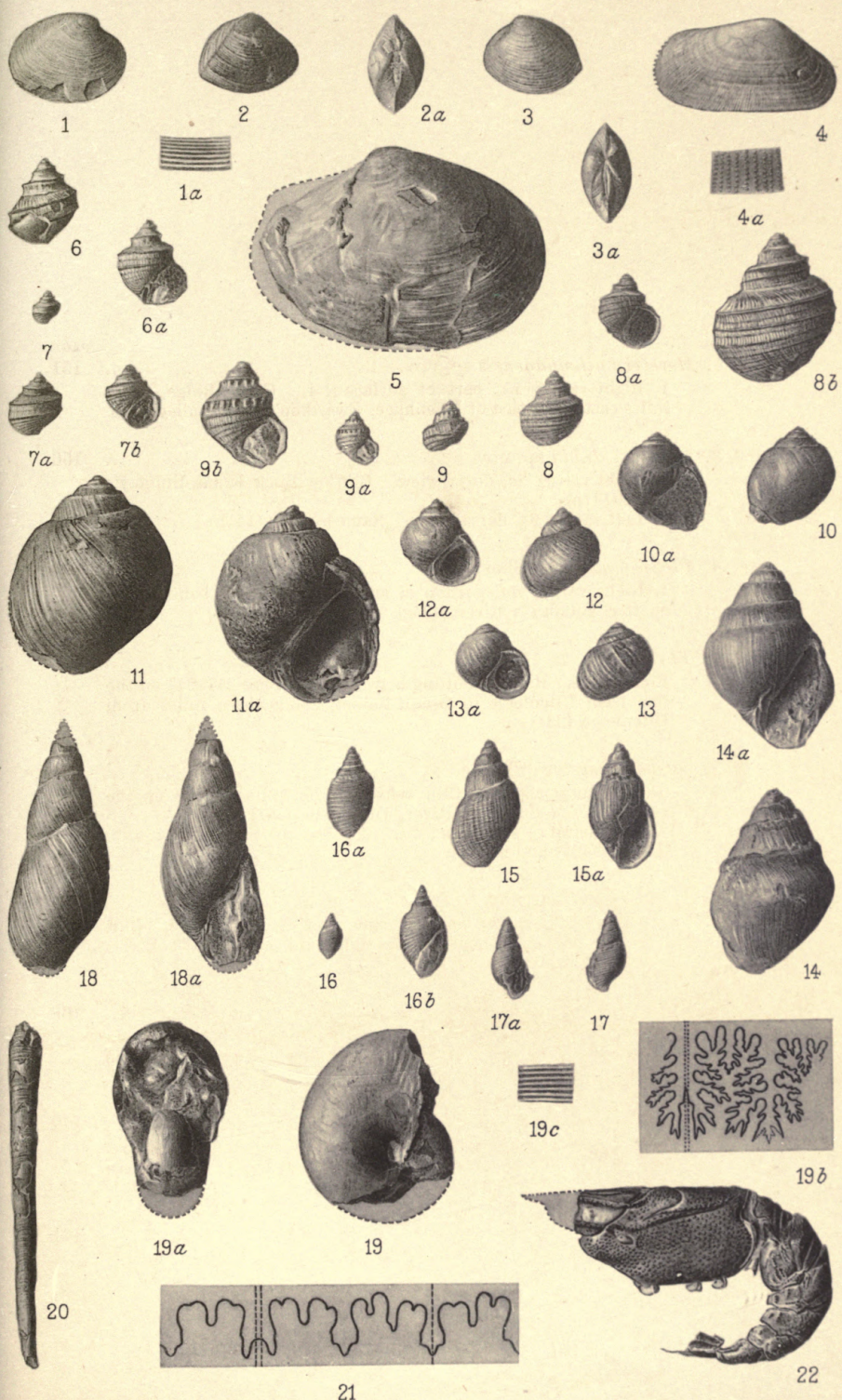




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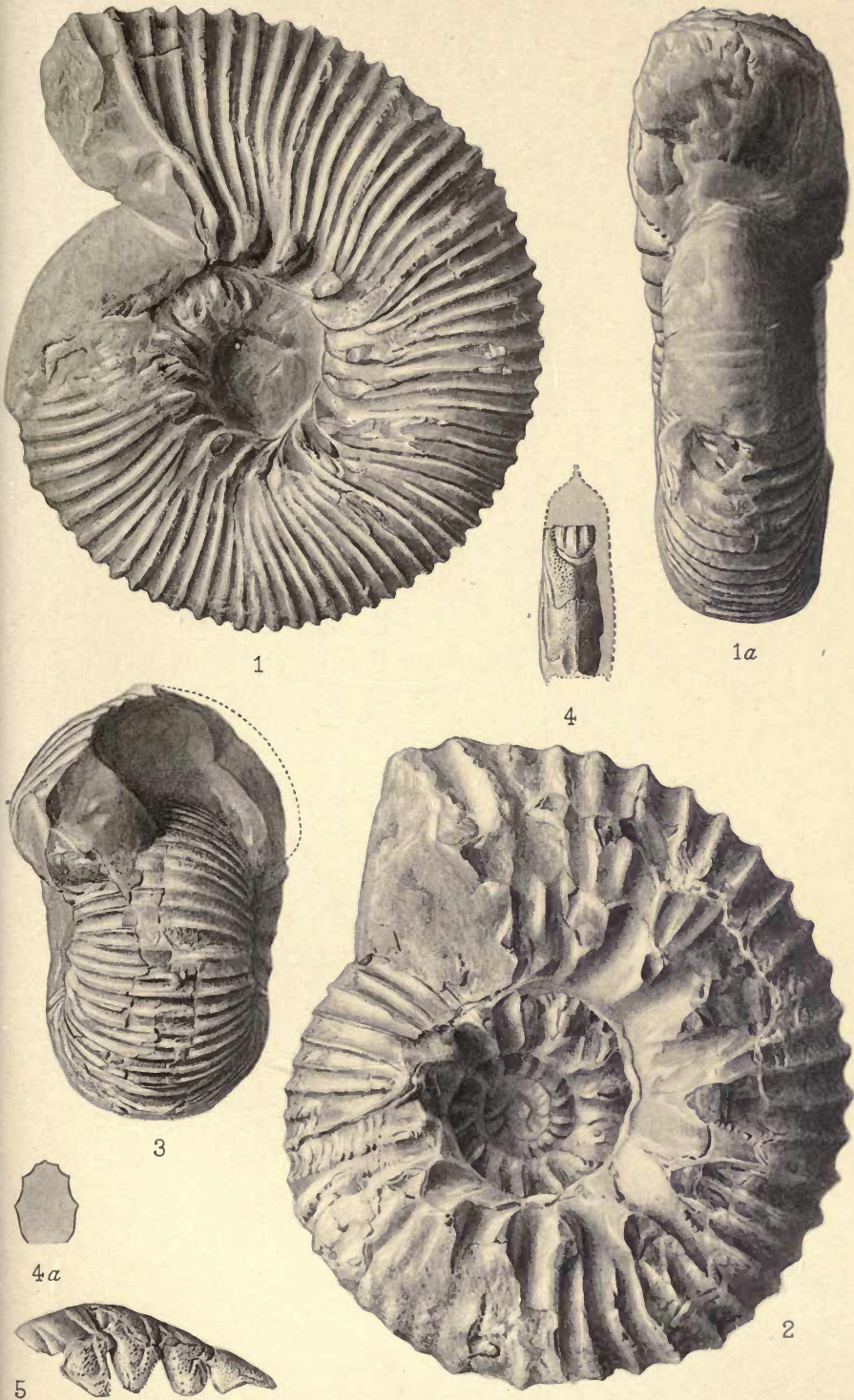
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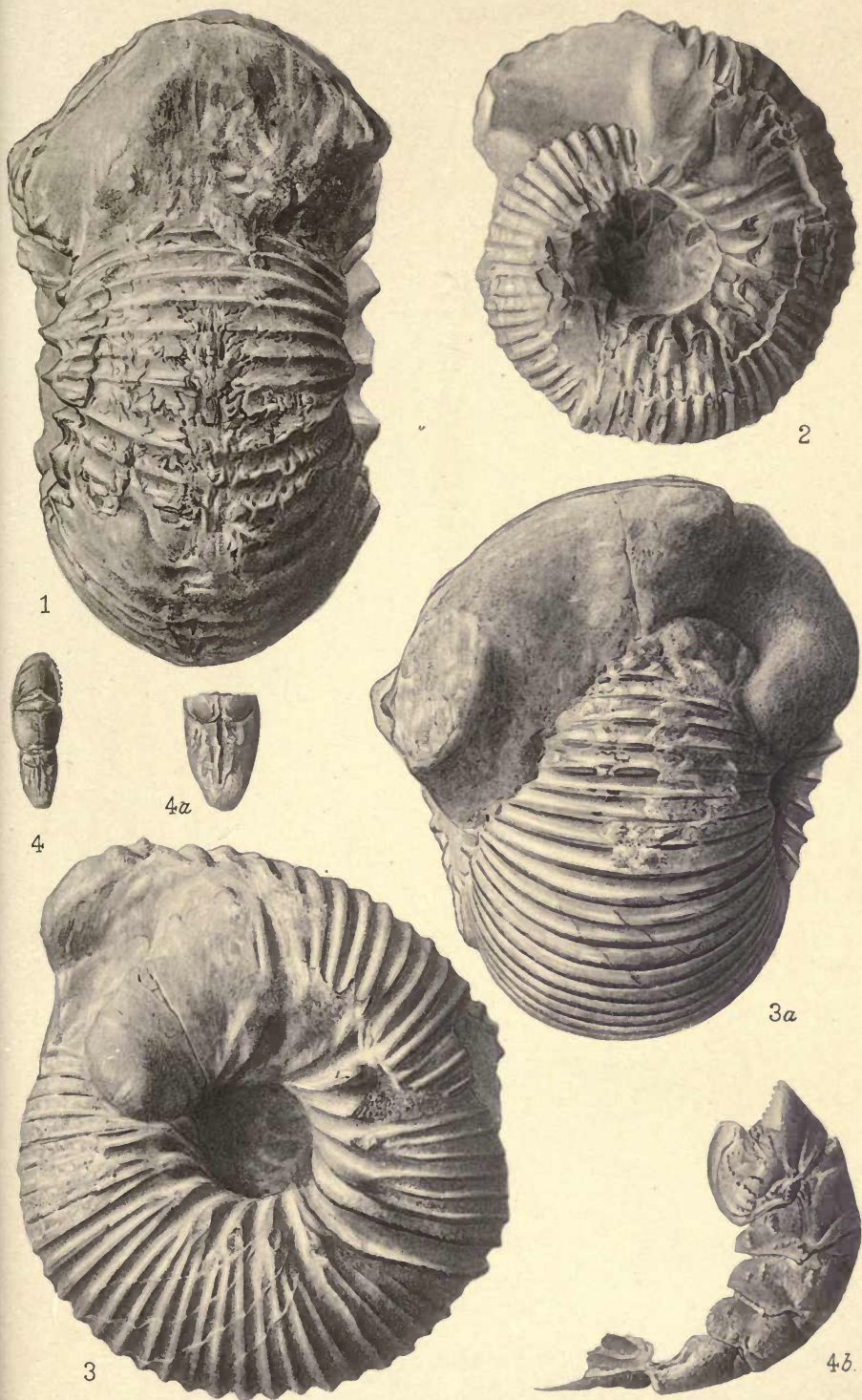




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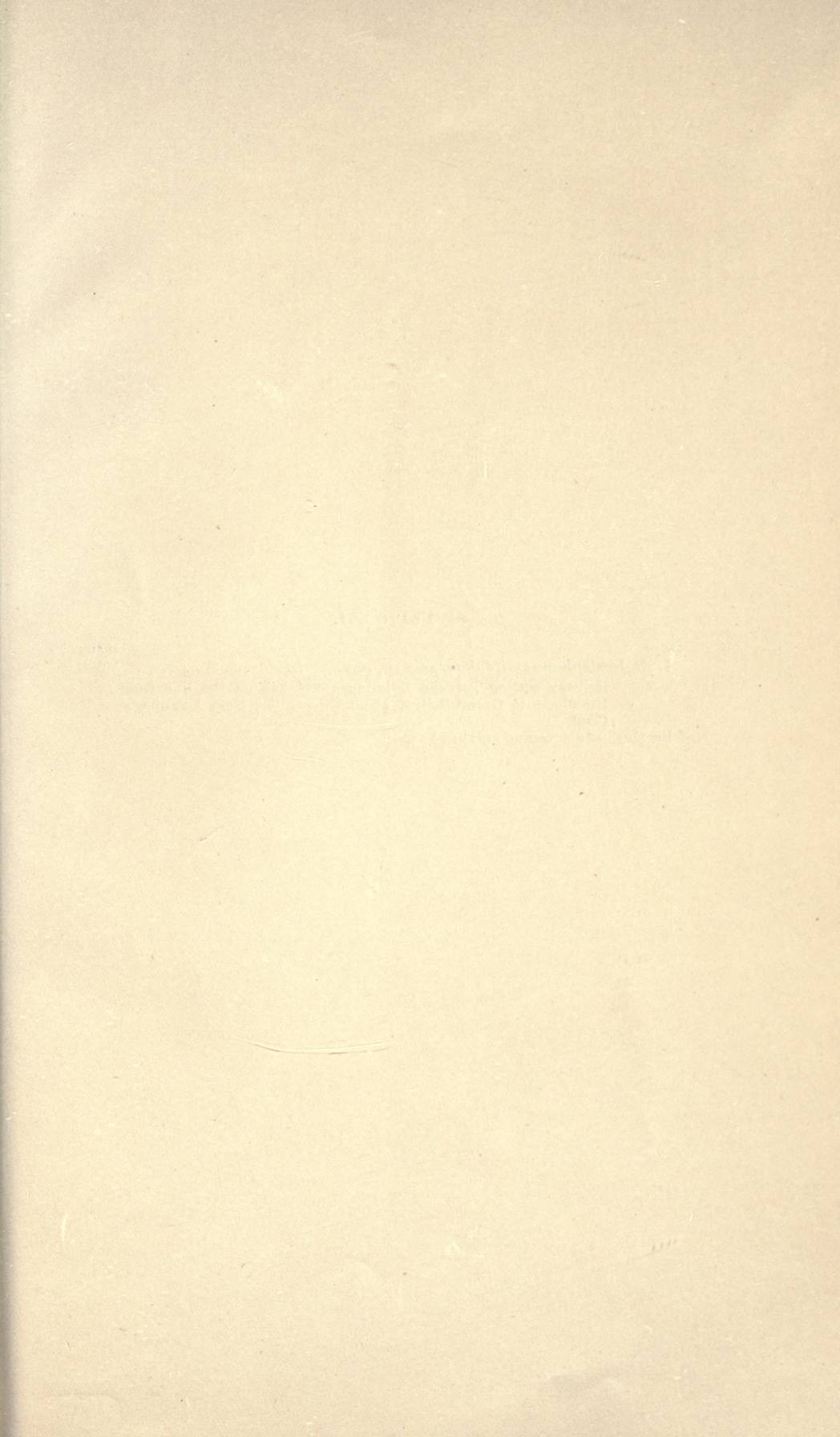
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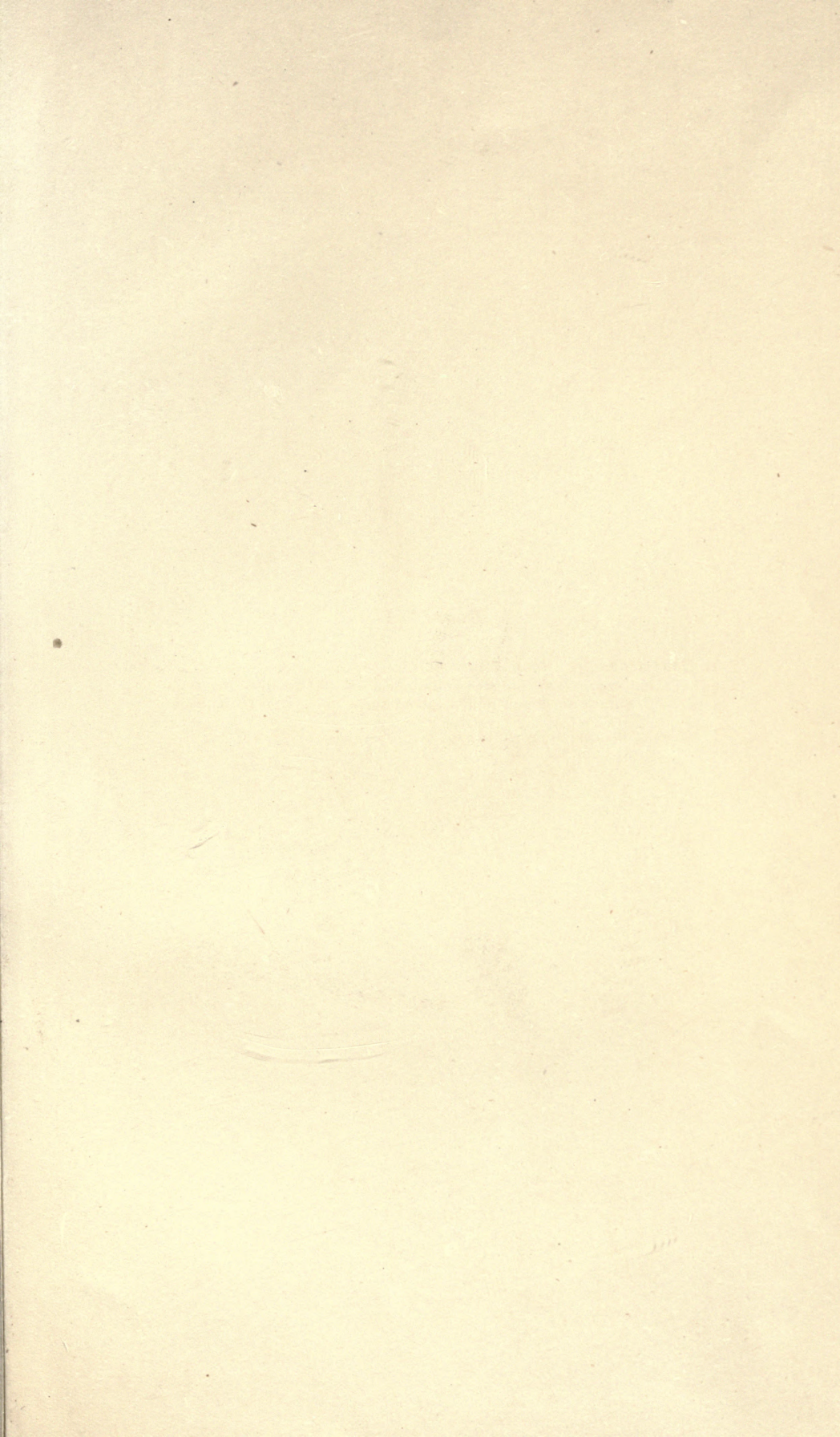
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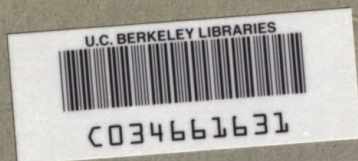
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